

Stanford University

Impact: Stanford University's Economic Impact via Innovation and Entrepreneurship

October 2012

Charles E. Eesley, *Assistant Professor in Management Science & Engineering; and
Morgenthaler Faculty Fellow, School of Engineering, Stanford University*

William F. Miller, *Herbert Hoover Professor of Public and Private Management Emeritus;
Professor of Computer Science Emeritus and former Provost, Stanford University and Faculty
Co-director, SPRIE*

About the authors:

Charles Eesley, is an assistant professor and Morgenthaler Faculty Fellow in the department of Management Science and Engineering at Stanford University. His research interests focus on strategy and technology entrepreneurship. His research seeks to uncover which individual attributes, strategies and institutional arrangements optimally drive high growth and high tech entrepreneurship. He is the recipient of the 2010 Best Dissertation Award in the Business Policy and Strategy Division of the Academy of Management, of the 2011 National Natural Science Foundation Award in China, and of the 2007 Ewing Marion Kauffman Foundation Dissertation Fellowship Award for his work on entrepreneurship in China. His research appears in the Strategic Management Journal, Research Policy and the Journal of Economics & Management Strategy. Prior to receiving his PhD from the Sloan School of Management at MIT, he was an entrepreneur in the life sciences and worked at the Duke University Medical Center, publishing in medical journals and in textbooks on cognition in schizophrenia.

William F. Miller has spent about half of his professional life in business and half in academia. He served as vice president and provost of Stanford University (1971-1979) where he conducted research and directed many graduate students in computer science. Prior to Stanford he was Director of the Applied Mathematics Division at the Argonne National Laboratory where he actively engaged in developing computational science.

In 1968 Miller played a role in the founding of the first Mayfield Fund in venture capital as a special limited partner and advisor to the general partners along with four other Stanford faculty members. He became the Herbert Hoover Professor of Public and Private Management in the Stanford Graduate School of Business in 1979 and today is a co-director of the Stanford Program on Regions of Innovation and Entrepreneurship (SPRIE).

As President and CEO of SRI International (1979-1990) Miller opened the think tank to the Pacific Region, establishing the spin-out and commercialization program at SRI and the David Sarnoff Research Center (now the Sarnoff Corp.) as a for-profit subsidiary of SRI. He has served on the board of directors of several major companies. Miller co-founded SmartValley, Inc. and helped create CommerceNet and serves on its board of directors. He was a founding director of the Center for Excellence in Non-profits. He currently is a founder /chairman of Nanostellar Inc., and founder/chairman of Lumiette, Inc.

Miller is a Life Member of the National Academy of Engineering, Fellow of the American Academy of Arts and Science, Fellow of the American Association for the Advancement of Science, Life Fellow of IEEE and a member of Silicon Valley Engineering Hall of Fame. He received Japan's Okawa Prize, the DongBaeg Medal from the Republic of Korea, the David Packard Civic Entrepreneur Award, and many other awards. In 2009, Konkuk University, Seoul Korea, established the William F. Miller School of Management of Technology and named Miller Honorary Dean.

Miller received the BS(1949), MS(1951), PhD (1956) and Honorary DSc (1972) from Purdue University

We thank Stanford, Sequoia Capital, the Kauffman Foundation, the School of Engineering, and the Stanford Technology Ventures Program for their generous support of our research.¹

The views expressed herein are those of the authors and do not necessarily reflect the views of the Ewing Marion Kauffman Foundation, Sequoia Capital or Stanford. Any mistakes are the authors'.

¹ Additional Thanks: We deeply appreciate the help of several others at Stanford in the preparation of this report. In particular, Laura Breyfogle, Lisa Lapin, Jamie Beckett, Steve Stanghellini, Nancy Peterson, and Edie ¹ Additional Thanks: We deeply appreciate the help of several others at Stanford in the preparation of this report. In particular, Lisa Lapin, Laura Breyfogle, Jamie Beckett, Steve Stanghellini, Nancy Peterson and Edie Barry, Barry, along with others in the Alumni Association, Engineering School and University Communications. Katherine Ku, director for many years of the Stanford Technology Licensing Office, supplied all of the data on the TLO's history and operations. We appreciate the feedback and comments on early drafts of this report from Douglas Rivers (Stanford), Edward B. Roberts (MIT), David Hsu (Wharton) and Michael Lenox (UVA). We appreciate the significant help in the creation of the earlier draft of this survey, performed at MIT by our collaborators, Edward B. Roberts at MIT Sloan and David Hsu, PhD, faculty member at the University of Pennsylvania. Wesley Koo, Xochitl Watts, Michael Gucwa, Alexander Titus and Matt Pruchniewski made important contributions to the data analyses and presentations in this report. We are grateful for their assistance and hard work.

Table of Contents	Error! Bookmark not defined.
Creating an Entrepreneurial Ecosystem	12
History of Stanford and Silicon Valley	12
Analyzing Stanford’s Entrepreneurial Footprint	15
Case Study: Google Inc., the Global Reach of One Stanford Startup	17
Case Example: David Cheriton.....	25
Case Example: Andy Bechtolsheim	27
The BASES Study	29
Funding Startup Businesses	30
Study of Investors	34
Alumni Initiatives: Stanford Angels & Entrepreneurs Alumni Group.....	35
Case Example: Clint Korver	36
How Stanford’s Academic Experience Creates Entrepreneurs	37
Changing Patterns in Entrepreneurial Career Paths.....	42
Case Example: Eric Krock.....	46
Stanford Centers and Programs for Social Entrepreneurs	47
Case Example: Miriam Rivera.....	48
Creating Non-Profit Organizations.....	49
The Lean Startup – Sticking to the Original Vision	53
How Stanford Supports Entrepreneurship – Programs, Centers, Projects, etc.	61
Stanford Technology Ventures Program	62
Mayfield Fellows Program	62
Entrepreneurship Corner.....	64
Conferences and Workshops	64
EpiCenter - National Center for Engineering Pathways to Innovation	66
Other Stanford Programs Supporting Entrepreneurship.....	66
Clubs and Student Groups	71
Academic Publications	75
Stanford Research.....	76
Stanford Academic Organization.....	77
From Scientific Research to Commercial Products.....	78
Success of Funded Research.....	80
Stanford Internal Entrepreneurial Ecosystem: The Office of Technology Licensing....	80
Company Formation: technology transfer	81

OTL Staffing and Operating Budget	82
Funding for Technology Startups	83
Impact of Technology Transfer on Tenure Review at Stanford	83
Best Practices Related to Stanford’s Technology Transfer Process	83
Results of Stanford’s Technology Transfer Process.....	85
Business Expansion/Attraction/Partnerships	90
Incentives Supporting Existing Businesses	92
Growth of Businesses as a Result of Collaboration.....	94
Business Relocation as a Result of Collaboration	94
Conclusions: Enhancing the Role of Research/Technology Universities in Innovation and Entrepreneurship	96
Appendix: Sources of Information	96
Company Database	96
Alumni Survey	96
Estimation Methods	96
STANFORD UNIVERSITY 2011 INNOVATION SURVEY.....	96
Estimation Methods	98
Benchmark Comparison of Stanford Alumni Firms to Other Universities	100
An Explanation of Scale Factors Used	102
References	103

EXECUTIVE SUMMARY

Stanford University has a deep history in entrepreneurship and technological innovation. For more than a century, the university has incubated ideas, educated entrepreneurs and fostered breakthrough technologies that have been instrumental in the rise and constant regeneration of Silicon Valley, and at the same time, contributed to the broader global economy.

Stanford graduates have founded, built or led thousands of businesses, including some of the world's most recognized companies – Google, Nike, Cisco, Hewlett-Packard, Charles Schwab, Yahoo!, Gap, VMware, IDEO, Netflix and Tesla. In the area of social innovation, the Stanford community has created thousands of non-profit organizations over the decades, including such well-known organizations as Kiva, the Special Olympics and Acumen Fund.

This report focuses on data gathered from a large-scale, systematic survey of Stanford alumni, faculty and selected staff in 2011 to assess the university's economic impact based on its involvement in entrepreneurship. The report describes Stanford's role in fostering entrepreneurship, discusses how the Stanford environment encourages creativity and entrepreneurship and details best practices for creating an entrepreneurial ecosystem.

The report on 2011 survey, sponsored by the venture capital firm Sequoia Capital, estimates that 39,900 active companies can trace their roots to Stanford. If these companies collectively formed an independent nation, its estimated economy would be the world's 10th largest. Extrapolating from survey results, those companies have created an estimated 5.4 million jobs and generate annual world revenues of \$2.7 trillion.

Other key findings of the survey include:

- 29 percent of respondents reported being entrepreneurs who founded an organization (for-profit or nonprofit)
- 32 percent of alumni described themselves as an investor, early employee or a board member in a startup at some point in their careers. 25 percent of faculty respondents (some of whom are also alumni) reported founding or incorporating a firm at some point in their careers.
- Among survey respondents who became entrepreneurs in the past decade, 55 percent reported choosing to study at Stanford because of its entrepreneurial environment.

The Stanford Innovation Survey went out to 143,482 alumni out of 191,332 total living Stanford degree-holders from the 1930s to the present. There were 27,783 responses with proportional representation from all seven schools, for an overall response rate of 19 percent. In addition, a total of 1,903 faculty received surveys and we received 1,134 faculty responses for a 59.6 percent response rate. Unfortunately, founders from some the largest companies founded by Stanford alumni -- HP, Cisco, Google and others -- weren't able to respond to the survey, so the number stated above and throughout this report are conservative and may not represent the full impact of Stanford entrepreneurship.

REGIONAL AND LOCAL IMPACT

Stanford alumni maintain their ties to the university, the Bay Area and the state. They return to campus to recruit, lecture, collaborate in research and advise current students. Forty percent of Stanford students find jobs through some form of networking, and the men and women who lead Silicon Valley's most innovative companies interact regularly by visiting

campus to lecture, collaborate with faculty, and share ideas with the next generation of entrepreneurs currently filling classrooms.

According to the survey:

- An estimated 18,000 firms created by alumni are headquartered in California, generating annual worldwide sales of about \$1.27 trillion and employing more than 3 million people.
- Among those who graduated after 1990, 25 percent of the responding entrepreneurs formed their companies within 20 miles of the university. (For engineers whose companies populate Silicon Valley, that that figure rises to 31 percent.) Thirty-nine percent of all alumni founded firms located within 60 miles of Stanford—or roughly a one hour’s drive.
- 15 percent (2,600) of graduate students from outside the United States stayed in the Bay Area and contribute to the region’s robust infrastructure and entrepreneurial spirit. [Since 1984, almost 44 percent (17,265) of Stanford’s graduate students have come from outside the United States. That percentage has increased in recent years to 56 percent in 2010.]

STANFORD’S APPROACH

How does Stanford create this entrepreneurial ecosystem? No matter what their major, students in all schools receive their education in the context of a robust liberal arts environment that gives them the broad world view they need to be the innovators and leaders of tomorrow. The university encourages networking and collaboration across disciplines and schools, offers opportunities for testing ideas and encourages students to become involved in research and prototype their ideas.

In addition, Stanford has for many years provided education specifically designed to encourage and develop entrepreneurs. The university began offering classes in small business and entrepreneurship as enrollment mushroomed after the Second World War. Today, it offers dozens of courses and programs that educate and support potential entrepreneurs, including:

- *LaunchPad*, offered through the School of Engineering’s Hasso Platner Institute of Design (widely known as the d.school), is a 10-week course in product design and development in which student teams imagine, prototype, build, market, distribute and sell a product or service.
- *Creating a Startup*, a two-quarter course offered by the Graduate School of Business (GSB), is team-taught by Stanford faculty, serial entrepreneurs in Silicon Valley and members of local venture capital firms. *The Spirit of Entrepreneurship*, a School of Engineering course offered to undergraduates and graduate students, brings in speakers for the Entrepreneurial Thought Leader seminars to discuss topics like venture financing and business models that influence a successful startup.
- *iPhone Application Development*, a 10-week course taught by Apple engineers. Offered as a Stanford course as well as a free, downloadable course through iTunes U (grades, credits and access to faculty are only available to Stanford students), it has proven enormously popular. Many of the apps created as a result of course assignments are now sold through Apple’s App Store.

More broadly, both the Graduate School of Business and the School of Engineering offer entrepreneurship curricula. The business school does this through its Center for Entrepreneurial Studies (CES) and the Stanford Venture Studio, a workspace for students exploring startups and entrepreneurial skills. The engineering school's classes are through the Stanford Technology Ventures Program (STVP), the Hasso Plattner Institute of Design and other entities. All of these programs are open to students throughout the university.

Stanford's approach to entrepreneurship education is to bring together cutting-edge theory and real-world expertise in the classroom. Classes may be taught by tenure-track faculty as well as seasoned entrepreneurs, veterans of the startup process who share their experiences and insights and may even provide key introductions to funders.\

Stanford's approach to entrepreneurship education is to bring together cutting-edge theory and real-world expertise in the classroom. Consulting faculty at the Business School and the School of Engineering—many from local firms—collaborate in teaching highly popular courses such as:

- Google chairman Eric Schmidt, venture capitalist Peter Wendell, and Stanford alumnus Andy Rachleff—respective co-founders of Sierra Ventures and Benchmark Capital—have team-taught *Entrepreneurship and Venture Capital*.
- Entrepreneur and venture capitalist Peter Thiel recently taught a class in the Computer Science Department about startups.
- Irv Grousbeck, co-founder of Continental Cablevision (later Media One) and a co-owner of the Boston Celtics, has taught entrepreneurship at the business school since 1985.
- Debra Dunn, formerly a senior executive at Hewlett-Packard, teaches in the School of Engineering's Hasso Plattner Institute of Design, including the course, *Designing for Sustainable Abundance*.
- IDEO partner Christopher Flink co-teaches *Brands, Experience and Social Technology*—an interdisciplinary experiment in teaching innovation—with Graduate School of Business professor Jennifer Aaker at the Hasso Plattner Institute of Design.
- Steve Blank, a serial entrepreneur and founder of Epiphany, and venture capitalists Ann Miura-Ko and Jon Fieber teach *Technology Entrepreneurship and Lean Startups* in the Stanford Technology Ventures Program.

According to the 2011 Stanford Innovation Survey, technical innovators—those who created new products, production processes or business models—and entrepreneurs were more likely than other alumni to have participated in entrepreneurship courses and programs. Approximately 25 percent of the technical innovators and founders reported taking an entrepreneurship course at Stanford, including 60 percent of the “quick founders”—those who received VC funding within three years of graduation.

Competitions and programs for students also attract future entrepreneurs. The survey showed that 35 percent of technical innovators, 40 percent of founders and more than 50 percent of quick founders participated in E-Challenge, STVP, the Center for Entrepreneurial Studies, d.school or other entrepreneurship programs. All three categories of innovators were also much more likely to have used the alumni network, particularly for identifying funding, co-founders, early hires and mentors.

Mentorship at Stanford happens through formal relationships, such as those between adviser and student, and more informally through networking and proximity. The university extensively involves visiting entrepreneurs, consulting faculty, lecturers and fellows, and office

hours for these individuals can quickly move from suggesting specific assignments to relaying war stories or providing real-time strategy sessions.

Many faculty members extend their mentoring to local companies by serving on boards. For example, Stanford professors Terry Winograd, Jeff Ullman and Rajeev Motwani moved from informal roles advising two graduate students—Larry Page and Sergey Brin, who became the founders of Google—to formal roles on the company’s technical advisory board in its early years.

Stanford President John Hennessy is a member of boards of Google and Cisco Systems. School of Engineering Dean James Plummer serves on the boards of Intel, International Rectifier and Cadence Design Systems. Graduate School of Business Dean Garth Saloner serves on the boards of Quick Response Services, Brilliant Digital Entertainment, NextStage Entertainment and Tradeweave Inc.

The faculty brings domain expertise to the companies related to new technologies. This service, in return, gives academicians insights into industry challenges and consumer opportunities that often help to define long-term research.

Other programs for mentoring and networking include:

- The Stanford Technology Ventures Program’s Mayfield Fellows Program provides mentoring and networking activities for gifted undergraduates or co-terminal (BA and MA/ MS) students.
- The Hasso Plattner Institute of Design offers courses that focus on projects developed with industry partners. Classes involve teams of designers, engineers, social scientists and business students and often focus on identifying and solving problems or coming up with devices and innovations to satisfy real-world needs.
- The Stanford Institute for Innovation in Developing Countries (SEED) seeks to stimulate, develop and disseminate research and innovations that enable entrepreneurs, managers and leaders to alleviate poverty in developing economies.
- The Stanford Venture Studio is a workspace at the Graduate School of Business for students exploring startups and entrepreneurial skills.

Mentoring and career development programs also make it more likely graduates will remain near campus. Numerous entrepreneurship associations on campus, such as Stanford Entrepreneurship Network (SEN), the Business Association of Stanford Entrepreneurial Students (BASES), encourage this retention.

The continuing engagement with the university by graduates who have founded companies provides research, jobs and other opportunities for students. In 2011, for example, local businesses offering summer internships to Stanford students included Facebook with 35 interns, and LinkedIn and Palantir Technologies, with 25 each.

NONPROFITS AND SOCIAL INNOVATION

In addition to founding businesses, Stanford graduates created some 30,000 nonprofit organizations. These include such world-renowned organizations as The Special Olympics, founded by Eunice Kennedy Shriver, a Stanford sociology graduate; and Kiva, a microfinance organization started by Jessica Jackley, a Stanford MBA, and Matt Flannery, with degrees in symbolic systems (BS) and philosophy (MS).

Other well-known nonprofits include Acumen Fund, global venture fund aimed at alleviating poverty co-founded in by Stanford MBA Jacqueline Novogratz, and MentorNet,

created by Carol B. Muller, a Stanford engineering alumnus, to help university engineering and science students – especially women and minorities – achieve their career goals by matching them with mentors and guiding their one-on-one relationships over the Web.

But the majority of these nonprofits are small grassroots organizations that collectively have had impact in education, global health or healthcare, the arts, economic development, human rights and many other areas.

At the same time, a growing number of graduates have pursued social innovation – the idea of doing well by doing good. Two of the best-known of these enterprises are Sally Ride Science, a science education company founded by astronaut Sally Ride, and Embrace, providers of an affordable infant warmer for the developing world that was created by four students enrolled in the university's *Design for Extreme Affordability* course.

ALUMNI FOUNDERS AND LEADERS

Below are just some of the Stanford alumni who have founded major companies (list is ordered by year company was founded):

- David Packard and Bill Hewlett, co-founders, Hewlett-Packard, Palo Alto, CA (1939)
- Russell H. and Sigurd F. Varian, William Webster Hansen, and Edward Ginzton, Varian Associates (1948) [Varian split into three companies in 1999. Varian Inc. is located in Palo Alto, CA]
- Joe Coulombe, founder and former CEO, Trader Joe's, Monrovia, CA (founded as Pronto Markets, 1958)
- Ray Dolby, founder and chairman of Dolby Labs, San Francisco (1965)
- Doris Fisher, co-founder, Gap Inc., San Francisco, CA (1969)
- Charles Schwab, founder and chairman, Charles Schwab Corp., San Francisco, CA (founded in 1971 as First Commander Corp.)
- Phil Knight, founder and chairman, Nike, Beaverton, OR (1972)
- Andreas Bechtolsheim, Scott McNealy and Vinod Khosla, co-founders (with Bill Joy), Sun Microsystems, Santa Clara, CA (founded 1982; acquired by Oracle in 2010)
- Judy Estrin, serial entrepreneur (JLABS Inc, Precept Software, Bridge Communications (1981)
- Jim Clark, Silicon Graphics, Mountain View, CA (1981; acquired)
- Trip Hawkins, founder and CEO of Electronic Arts, Redwood City, CA (1982)
- T.J. Rodgers, Cypress Semiconductor, San Jose, CA (1982)
- Heidi Roizen, co-founder and CEO of T/Maker Company (1983)
- Leonard Bosack and Sandy Lerner, co-founders of Cisco Systems, San Jose, CA (1984)
- Morris Chang, founder and chairman, TSMC, Hsinchu, Taiwan (1987)
- Peter Thiel, Ken Howery, co-founders (with others), PayPal, San Jose, CA (founded 1988; acquired by eBay, 2002)
- David Kelley, founder of IDEO, Palo Alto, CA (1991)
- Jen-Hsun Huang, founder and CEO of Nvidia, Santa Clara, CA (1993)
- Jerry Yang and David Filo, founders of Yahoo!, Sunnyvale, CA (1994)
- Reed Hastings, founder and CEO of Netflix, Los Gatos, CA (1997)

- Larry Page and Sergey Brin, founders of Google, Mountain View, CA (1998)
- Tim Westergren, Jon Kraft, co-founders (with Will Glaser), Pandora Radio, Oakland, CA (2000)
- Reid Hoffman, Konstantine Geuricke, Allen Blue, Eric Ly and Jean-Luc Vaillant, LinkedIn, Mountain View, CA (2002)
- JB Straubel, co-founder, Tesla Motors, Palo Alto, CA (2003)
- Jeff Skoll, Participant Media, Los Angeles, CA (2004)
- Kevin Systrom and Mike Krieger, Instagram, San Francisco, CA (2010, acquired by Facebook 2012)

Creating an Entrepreneurial Ecosystem

HISTORY OF STANFORD AND SILICON VALLEY

Stanford University has been unconventional since its founding in 1885. It was in the West, open to women, non-denominational and dedicated to the formation of “*cultured and useful citizens*.” As the university’s first president David Starr Jordan said at the opening day celebration, Stanford “is hallowed by no traditions; it is hampered by none. Its finger posts all point forward.” That remains true 126 years later.

When Stanford University was founded, the surrounding area was largely undeveloped as an industrial region. California had been admitted as a state just 35 years earlier and Stanford was located in a largely undeveloped agrarian area. Although the gold rush that started in 1849 had run its course, the effects on the region were still felt. The Golden Spike that connected the West to the East by the First Transcontinental Railroad had been driven by Leland Stanford just 16 years earlier. The faculty, staff and students who joined Stanford in its early years can truly be described as pioneers. They bestowed upon the university a restless pioneering spirit that persists to this day.

Pioneers have two characteristics; they are adventurous and they are community builders. The first faculty and staff were dedicated to building Stanford as a great university but also to building the community. From the beginning, they worked on creating new companies. In the 1890's Stanford's first faculty member in electrical engineering, Professor Frederic Auten Combs Perrine, developed a more efficient electrical power transmission process. Professor Harris Ryan came to Stanford from Cornell in 1905 to head the Stanford Electrical Engineering faculty. He actively promoted university-industry cooperation as did William Durand, a leading authority on airplane propeller design.

By the 1890's radio transmission was "in the wind", and following Marconi's successful sending of a Morse Code signal across the Atlantic, interest in wireless transmission took a sudden jump. Stanford faculty and students began experimenting with ways to improve wireless transmission. The first regularly scheduled broadcasting station in the United States, "San Jose Calling", was established by Charles D. Herrold in 1912 just a few miles south. This inspired a number of "ham radio" builders, including Frederick Terman, son of Stanford faculty member, Lewis Terman, and Herbert Hoover Jr., son of Stanford graduate and future U.S. President Herbert Hoover.

The first major high tech company to be formed in what became Silicon Valley was Federal Telegraph, founded in 1909 by a recent Stanford graduate, Cyril Elwell. The company, originally called Poulson Wireless Telephone and Telegraph Company, was initially financed by the founder, Stanford faculty members and Stanford President David Starr Jordan, who invested \$500.00. Federal Telegraph grew to be a significant company and spawned other firms. Lee de Forest, the inventor of the three element vacuum tube and Federal's director of research, left to sell his audion improvements. Peter Jensen, C. Alberltus, and E.S. Pridham formed Magnavox, to build speakers for public meetings and for radio receivers. This pattern of individuals spinning out to form new startup companies became common in Silicon Valley and persists to this day.

Federal Telegraph built radio stations, developed communications equipment for the U.S. Navy, and developed consumer radio broadcast receivers. Its original core technology, the arc transmitter, was replaced by the radio vacuum tube, ushering in the era of radio. The South Bay Area, from Palo Alto to San Jose, developed the infrastructure for a high tech radio engineering industry, including suppliers and new application companies, many started by Stanford graduates or employing the well trained Stanford engineering graduates.

Terman's interest in radio was nurtured while working at Federal Telegraph as an undergraduate. After receiving his BS in chemistry, he took the advice of his faculty adviser, Professor Harris J. Ryan and went to MIT to work on his PhD. His research adviser was MIT Vice President and Dean of Engineering Vannevar Bush, who became the head of the U.S. Office of Scientific Research and Development during WWII and founded several companies. Bush became a leading advocate of university industry collaboration and fostered the collaboration among universities, industry, and the military.

From his previous experience at Federal Telegraph and his relationship with Vannevar Bush, Terman readily took to the idea of university-industry collaboration. When he returned to Stanford after receiving his PhD, he brought back with him a vision of a university-industry community in the San Francisco Bay Area.

J. Wallace Sterling, president of Stanford from 1948 to 1968, set the stage for Stanford's rise to national prominence. He appointed Terman as vice president and provost and the two made an outstanding team. In the 1950s Terman fostered the university-industry partnerships that led to the establishment of companies key to the high-technology revolution. Terman encouraged entrepreneurship among his students, created opportunities in California for Stanford-educated engineers, established continuing education programs for engineers in local companies and encouraged Stanford faculty to serve as consultants to industry and government within the limits of time permitted by the university.

Terman helped develop the university research park and actively recruited visionary companies starting with Varian Associates followed closely by Hewlett-Packard. The Stanford Research Park soon became both a knowledge center and an incubator for generations of new businesses and products. One of the largest research parks in the country and thought to be the first technology-focused park, it sits on about 700 acres of university land and houses 140 companies in just over 10 million square feet of space. It is a place where startups can find space to work, colleagues to bounce ideas off of, equipment to share and the constant stimulation that comes with new blood from the university.

Hewlett-Packard was an early supporter of Stanford Engineering's tutored video classes for industry. William Hewlett was fond of saying that one of Stanford's most valuable contributions to Silicon Valley was its constant generation of master's students who then pursued opportunities in the Valley. Today HP continues to be located there, along with employees of some 140 other companies including Facebook, Skype, Tesla Motors and Genencor. Technology may change, but the objective remains the same: to provide industry with access to the university and to offer researchers a chance to try out their ideas in the business world.

Terman also authorized and oversaw the Industrial Affiliates Program, which brings industry researchers together with faculty and students to discuss recent advances in their disciplines. As an example, the Stanford Computer Forum established in 1968 brings together computer science students, researchers and industrial leaders. The concept of a forum is a place where there is two-way interchange. Not only do the faculty and students in computer science discuss their work but also the industry researchers discuss their research and trends in product development. This two-way interchange gives rise to a culture of interest in industrial applications as well as fundamental research. Currently more than 60 local firms are members of the forum.

Semiconductors came to Silicon Valley in the 1950s. William Shockley established the Shockley Semiconductor Laboratory in Mountain View in 1955 as division of Beckman Instruments. Shockley had left the Bell Telephone Laboratories (BTL) in 1953 for Cal Tech. It was at Bell Labs that he had co-invented the transistor while working on solid state physics

devices with John Bardeen and Walter Brattain. The three were awarded the Nobel Prize in Physics in 1956. Shockley had recruited an outstanding group of young scientists such as Robert Noyce and Gordon Moore who in 1957 left Shockley Semiconductor Laboratory to form Fairchild Semiconductor Corp. In 1968 Noyce and Moore left Fairchild Semiconductor to form Intel Corporation. With the formation of the spinouts from Fairchild the semiconductor industry was off and running in what soon became known as Silicon Valley.

The Stanford program in solid state physics was beginning to produce graduates who went into the semiconductor companies in the Valley. Ted Hoff, one of the early graduates of the Stanford program, joined Intel Corporation and there invented the microprocessor, a computer on a chip. Stanford now was connected closely with the semiconductor through its many graduates in engineering. Some formed companies—for instance, T.J. Rogers created Cypress Semiconductor—while others played important roles in research and management.

In 1970 Stanford established the Office of Technology Licensing (OTL). The first emphasis of the OTL is not in producing revenues but rather to allow the inventions of faculty and students to become available for public use through a commercialization process. Today, the office is a recognized and innovative leader for enabling technology transfer for society's benefit. In four decades, it has generated more than 8,000 inventions, more than 3,000 licenses and more than \$1.3 billion in revenues for Stanford to further the research and education mission of the university.

Stanford also has initiated a large number of teaching programs, workshops, and mentoring programs to provide learning opportunities for those students as well as faculty who were interested in entrepreneurship.

References:

In preparing the above, we drew heavily on the following references.

1. "The Making of Silicon Valley: A One Hundred Year Renaissance", Ward Winslow Editor, The Santa Clara Valley Historical Association, 1995
2. "Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region", Martin Kenney Editor, Stanford University Press, 2000.
3. "Fred Terman at Stanford", C. Stewart Gillmore , Stanford University Press, 2004.
4. "The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship", Chong-Moon Lee, William F. Miller, Marguerite Gong Hancock, and Henry S. Rowen, Editors, The Stanford University Press, 2000.

Among the newest buildings in Stanford's Science and Engineering Quadrangle is the Jen-Hsun Huang Engineering Center, named after the Stanford electrical engineering graduate who co-founded NVIDIA Corp. The building is designed to inspire invention in an environment of creativity and collaboration.



Analyzing Stanford's Entrepreneurial Footprint

Today Stanford has a deep history in entrepreneurship and technological innovation. The achievements of the University and its alumni in this area are remarkable. However, Stanford is a balanced university and this level of excellence can be seen across the university. Like the Stanfords, the University's first president, David Starr Jordan, emphasized the balanced approach Stanford sought in his early writings on the University. "Work in applied science is to be carried out side by side with the pure sciences and humanities, and to be equally fostered," he wrote. The Humanities remain a cornerstone of undergraduate education at Stanford and external rankings bear this out.

In this report, we focus in on Stanford's role in the economy through data, yet we also highlight that this entrepreneurial spirit permeates the entire institution across disciplines and schools.

If companies founded by Stanford graduates were an independent nation, it would be the tenth largest economy in the world, based on responses to the 2011 Alumni Innovation Survey. Extrapolating from survey results, it is estimated that since the 1930s 39,900 active companies can be traced to Stanford, and those companies have created 5.4 million jobs and generate annual world revenues of \$2.7 trillion.

In early 2011, Assistant Professor Charles Eesley of the School of Engineering conducted a survey of all living Stanford alumni, faculty, and staff to examine their influence as innovators and entrepreneurs. The Stanford Innovation Survey went out to 143,482 alumni out of 191,332 total living Stanford degree-holders. Eesley received 27,700 responses with proportional representation from all seven schools, for an overall response rate of 24.2 percent. Out of those, 8,000 reported being entrepreneurs who founded any type of organization (for-profit or non-profit) and 4,290 said they had founded an incorporated business. Responses include data on 2,798 individuals who were early employees (16 percent of the alumni), 349 venture capital investors, and 2,572 angel investors. Some 3,600 respondents, 18 percent, said they had been on a private company board of directors. Respondents included 1,134 Stanford faculty members (from a total of 1,903 in 2011) and 974 members of Stanford's research staff. These non-

entrepreneur data are separately analyzed to provide broader insights into the Stanford-related innovation system.

In this report, (See page 101 for detailed description of research methods) we describe Stanford's role in the economy and how this can be estimated via our systematic survey. An entrepreneurial spirit permeates the entire institution across disciplines and schools, encompassing non-profits, as well as innovation in the creative arts and humanities. Stanford encourages and sustains this culture of innovation and entrepreneurship through programs that build a creative spirit, and which also draw people to the university who have an entrepreneurial spirit within themselves. Stanford plays an important role in attracting and retaining talent as well as building a highly skilled workforce in the Silicon Valley region.

Innovation from Stanford and Stanford alumni influences the world with direct and indirect economic contributions plus innovation not intended to have an economic impact. For instance, a good deal of innovation happens outside of technology and in the creative arts; 13.1 percent of alumni respondents reported generating innovations in this field. This report focuses mainly on measuring innovation that contributes directly to economic growth, including patents or scientific publications contributing to the success of individual firms. But, for example, 30.1 percent of alumni produced non-patented innovations, 25.8 percent created new business models and 21.8 percent generated innovations in business or legal practice (including financial innovation, new securities, or new lines of legal analysis).

Given Stanford's history and culture, we focus on the entrepreneurial impact of the Stanford community. Here 32 percent of alumni described themselves as an investor, early employee or a board member in an entrepreneurial firm at some point in their careers. Including those who directly founded firms, this number increases to 36.5 percent. In addition, 25 percent of faculty respondents (some of whom are also alumni) reported founding or incorporating a firm at some point in their careers.

Developing an entrepreneurial culture requires far more than just encouraging students and faculty to take innovative ideas to the marketplace and providing opportunities for venture capital funding. It requires creating an environment that encourages innovation at every turn—both in the classroom and outside of it. Stanford's strategy is to attract the best people to do cutting-edge work and to provide an environment that encourages innovation and supports the free flow of information. Flexibility is key to its success. Stanford understands that catching the next wave of innovation depends on agility and openness to change. The university's practices and programs encouraging innovation and entrepreneurship have developed and continue to evolve in response to the changing needs of society and the marketplace. This has enabled Stanford to approach entrepreneurship from different perspectives.

Stanford has well-developed policies for faculty, research staff, and students related to ownership of intellectual property. In many cases, however, the university will decline to pursue an ownership position if the ability to protect the technology is low and it can be easily replicated. For example, in 1994 when Stanford electrical engineering students Jerry Yang and David Filo created a website that was a directory of other websites and that eventually became Yahoo!, Stanford decided to provide the technology to the founders without a license. Such policies have provided a nurturing environment for entrepreneurs and resulted in countless innovations and advances in technology, as well as the creation of many startups.

The 2011 Innovation Survey found:

- 25 percent of faculty respondents, 22 percent of research staff respondents and 30 percent of alumni respondents had founded a company.
- Some 1,067 firms were founded by students while still at Stanford or within a year of graduation.
- Among survey respondents who became entrepreneurs in the past decade, 55 percent reported choosing to study at Stanford because of its entrepreneurial environment.

Startup Success Stories

Stanford's entrepreneurial culture provides great flexibility in launching startups. There are three general classifications for companies founded using non-proprietary intellectual property:

- Startups in which Stanford technology, but no license, is involved. These include Hewlett-Packard, Cisco, Sun and Yahoo!
- Startups with a Stanford connection but which were launched outside the university. Typically, these startups involve Stanford faculty or students who played key roles in the vision and technology creation. Examples include Affymetrix, IDEO and Rambus.
- Startups founded by alumni. Examples include Intuit, PayPal, Cypress Semiconductor, Netflix, Tesla, LinkedIn, Electronic Arts, NVIDIA and SunPower.

CASE STUDY: GOOGLE INC., THE GLOBAL REACH OF ONE STANFORD STARTUP

Google epitomizes the entrepreneurial culture at Stanford. It demonstrates the long-term relationship between academia and a startup and how an idea can move from the university to the marketplace, enabling a startup to become an industry leader. Larry Page and Sergey Brin met in 1995 as Stanford students. Both worked as part of a National Science Foundation sponsorship program, identifying ways to search digital libraries. Several search engines already existed, but their approach used citations from one publication to another (which they called "BackRub") and resulted in a more powerful search engine. After BackRub came PageRank, which searched the web rather than digital publications and served as a basis for the subsequent patent.

Brin and Page worked closely with their academic advisers, Stanford professors Terry Winograd and Jeff Ullman. They also consulted informally with other computer science professors including David Cheriton and with alumnus Andreas Bechtolsheim, cofounder of Sun Microsystems, as they incubated their project. After operating it on Stanford servers the first year, the students worked with Stanford's Office of Technology Licensing to establish a licensing agreement.

In 1998, Google filed for incorporation, hired its first employee—a fellow student in the Computer Science Department at Stanford—and moved to a tiny office in downtown Palo Alto. The name was a nod toward "googol," a mathematical term for the number 1 followed by 100 zeros—reflecting their ambitious goal of organizing the world's information to make it both accessible and useful.

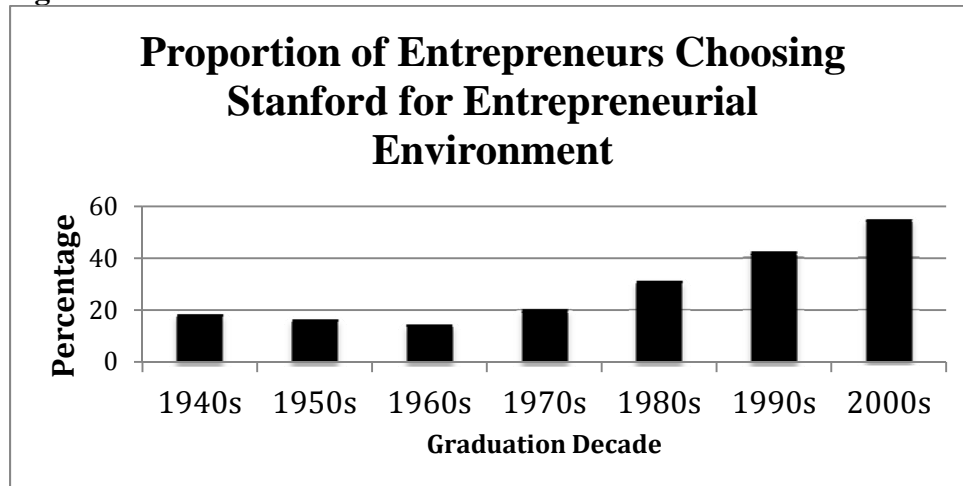
Several other Stanford graduates formed the core team, including Marissa Mayer, Craig Silverstein and Mehran Sahami. By 1999, Sequoia Capital and Kleiner Perkins Caulfield &

Byers—local venture capital firms with Stanford alums as partners—provided \$25 million in venture capital to the startup. A year later Google won its first two Webby Awards recognizing excellence on the Internet and became the world’s largest search engine with its first billion URL index.

Over the next few years, Google grew, adding features, products and experienced personnel. Stanford alumni who joined included Omid Kordestani, who became vice president for worldwide sales and operations; and Alfred Spector, vice president of research and special initiatives. Today approximately 1,300 of Google’s 33,000 employees worldwide are Stanford graduates. Google’s initial public offering was in August 2004 and by 2011 its estimated revenue was in excess of \$37 billion. It invests in cloud computing and advertising technologies as well as in search.

The relationship between Google and Stanford University continues to develop and advance information technology. Google has endowed graduate fellowships, a professorship and supports some 40 technology projects at Stanford. The company has licensed Stanford inventions, such as research professor Sebastian Thrun’s technology that is incorporated into Google’s Street View, and has acquired some university spin-offs. Many Stanford faculty members have spent leave time engaged in research at the company and every year many Stanford students serve as interns at Google.²

Figure 1



Among survey respondents who became entrepreneurs in the past decade, 55 percent reported choosing to study at Stanford for its entrepreneurial environment.

² Compiled by Stanford in 2011 for a New York City campus proposal.

The Types of Companies Stanford Graduates Create

Table 1 shows a small selection of important firms founded by Stanford graduates that have market values of over \$10B as of December 2011. Many other companies could be added to this list. Most of the firms shown here are conservatively omitted from the economic impact projections in the 2011 Innovation Study due to founder deaths, company mergers or non-response to the survey.

Table 1 Large Companies Founded by Stanford Alumni

Below are 12 U.S. companies with Stanford ties that have current market values of over \$10B as of December 2011.

Company	Valuation (\$B)	Revenues (\$B)	Employees	Stanford Founder	Stanford Degrees	Founding Year
Google	\$189	\$37.9	32,467	1) Sergey Brin; 2) Larry Page	1) MS CS 95; 2) MS CS 98	1998
Cisco	\$94	\$43.2	71,825	1) Leonard Bosack; 2) Sandra Lerner	1) MS CS 81; 2) MS Stats 81 (I believe she was also staff)	1984
Hewlett-Packard	\$88	\$126	324,600	1) William Hewlett; 2) David Packard	1) BA 34, EE 39; 2) BA 34, MS EE 38	1939
Nike	\$41 ³	\$20.9 ⁴	38,000 ⁵	Philip Knight	MS Business 62	1964
VMWare	\$34	\$2.9	9,000	1) Edouard	1) MS CS 96,	1998

³ Source: http://ycharts.com/companies/NKE/enterprise_value, July 16, 2012

⁴ Nike 2010 Annual Report

⁵ Nike 2010 Annual Report

				Bugnion; 2) Mendel Rosenblu m	PHD CS 12 2) CS Faculty	
Yahoo!	\$20	\$6.3	13,600	1) Jerry Yang; 2) David Filo	1) BS EE 90, MS EE 90; 2) MS EE 90	1994
NetApp	\$18	\$5.1	10,212	1) James Lau; 2) Michael Malcolm	1) MS CS 82; 2) MS CS 71, PHD CS 73	1992
Gap, Inc.	\$17	\$14.5	132,000	Doris Fisher	BS Econ 53	1969
Charles Schwab	\$16 ⁶	\$4.7 ⁷	14,100 ⁸	Charles Schwab	BA EC 59, MS Busines s 61	1971
Intuit	\$16	\$3.9	8,000	Tom Proulx	BS EE 83	1983
Altera	\$14	\$2	2,666	Jim Sansbury	BS EE 66, MS EE 67, PHD EE 71	1983
Intuitive Surgical	\$13	\$1.4	1,660	Frederic Moll	MS Busines s 88	1995
Netflix	\$12	\$2.2	2,180	Reed Hastings	MS CS 88	1998
Nvidia	\$10	\$3.5	6,029	Jen-Hsun Huang	MS EE 92	1993
Total	\$582	\$275	666,339			

Listing compiled by the authors, 2012.

⁶ <http://ycharts.com/companies/SCHW>, July 16, 2012

⁷ THE CHARLES SCHWAB CORPORATION 2011 Annual Report

⁸ THE CHARLES SCHWAB CORPORATION 2011 Annual Report

In Table 2 we divided the firms according to an index based on their level of innovation (utilizing answers to several questions in the survey), identifying the top quartile of the most innovative (heavy innovation), a second category of moderately innovative and then the remainder of the firms that may be relying more on competitive advantages related to cost efficiency or new market segments. We found that among all Stanford-affiliated firms, those classified as moderately or heavily innovative accounted for a disproportionate share of the employment and revenues.

Table 2

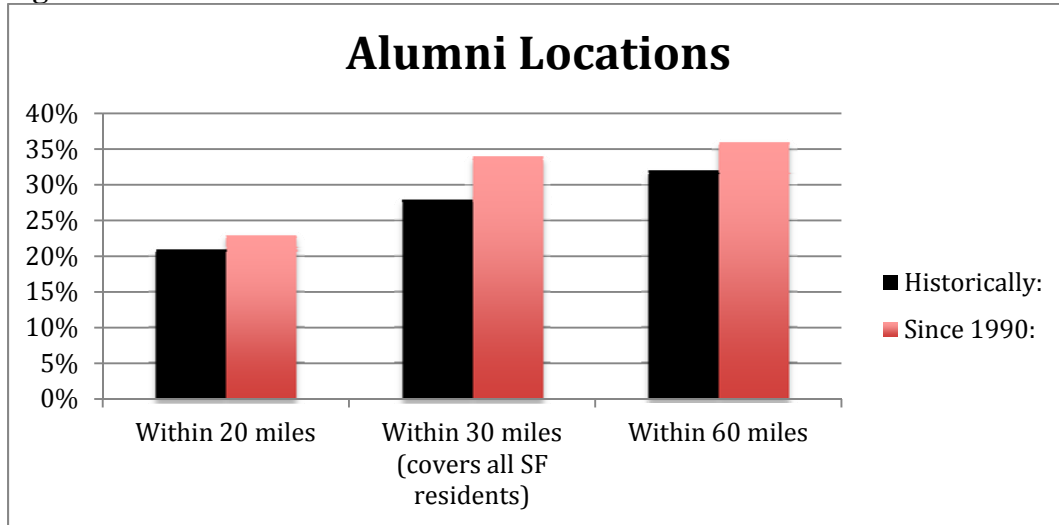
	Heavy Innov	Moderate Innov	Little Innov	Total
Percent of firms	25%	25%	50%	100%
Revenue (in millions of \$)	\$1,270,000	\$531,000	\$864,000	\$2,667,000
% of total revenues by all Stanford firms	48%	20%	32%	100%
Employees	1,141,000	2,003,000	2,242,000	5,387,000
% of total employment by all Stanford firms	21%	37%	42%	100%

In Table 3 we divide the firms according to size (a division commonly used in prior studies), we find a highly skewed distribution in firm sizes. Most of the firms have fewer than 1,000 employees and a small percentage of firms become very large. We find that in the aggregate, small firms are very important, but the middle and largest size categories account for a disproportionate share of the aggregate employment and sales. This is true despite the fact that the smallest size category includes 97% of the firms.

Table 3

	Percent of firms	median emp#	median rev (\$mil)	Est. aggregate total emp#	Est. aggregate total sales (\$mil)
Less than 1000	97%	10	\$1	1,762,000	\$1,711,000
1,000–10,000	2.6%	1,947	\$250	2,248,000	\$704,000
More than 10,000	0.3%	16,000	\$1,950	1,377,000	\$251,452
Total	100%	11	\$1.2	5,387,000	\$2,667,000

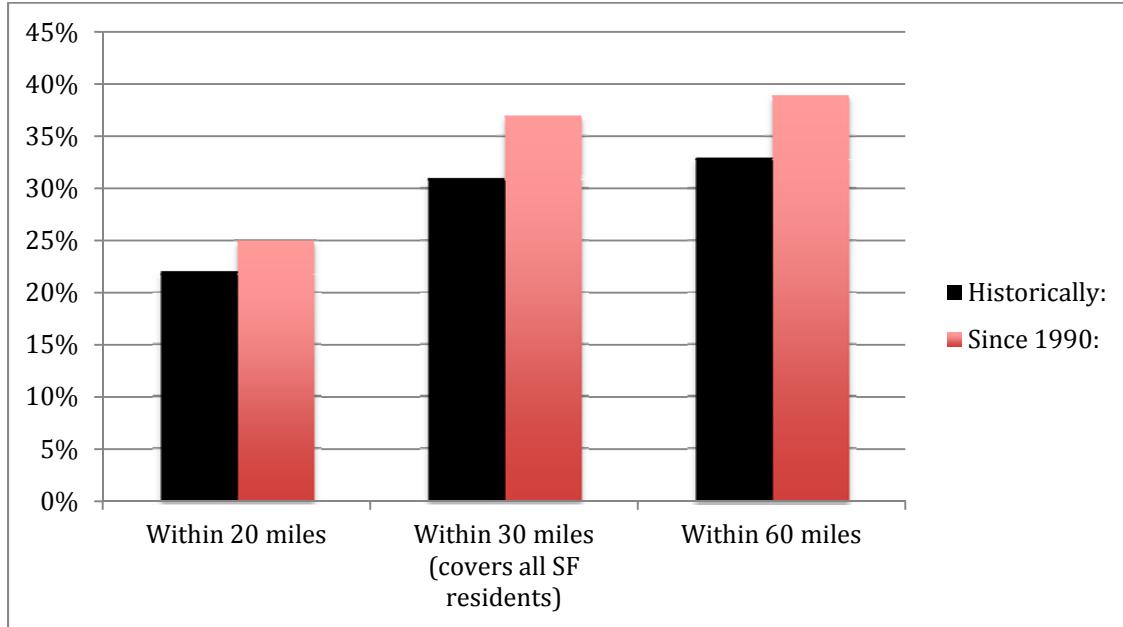
Figure 1



Entrepreneurs are even more likely than the other alumni to locate in the immediate area. There has been an increase in recent years in both entrepreneurs and alumni remaining in the area around the university.

Stanford’s location means California has for many years been “importing” company founders, men and women drawn to Stanford from other areas of the country and the world who then stay in California to found companies. The estimated 18,000 Stanford alumni firms headquartered in California generate worldwide sales of about \$1.27 trillion. Although less than 35 percent of Stanford freshmen are residents of California, a full 45 percent of the companies founded by graduates are located in California.

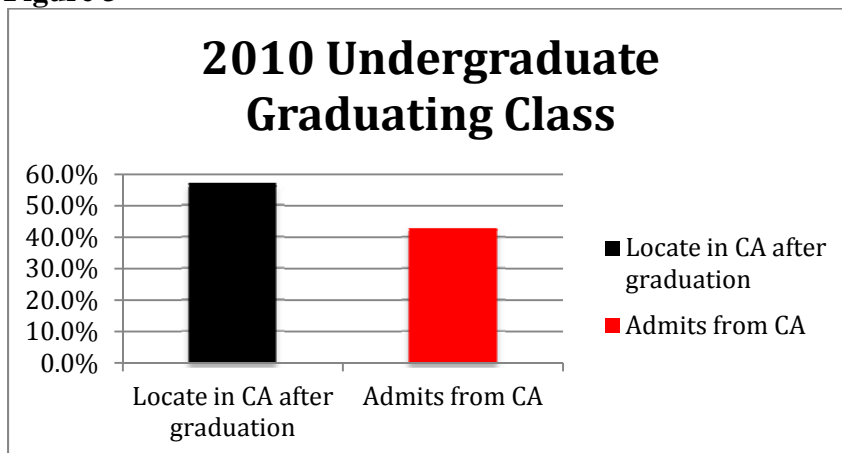
Figure 2 Where Companies are Located



Many Stanford alumni remain in the Bay Area after graduation. Specifically, from 2001 to 2010, the following alumni have remained near campus:

- 47.6 percent (5,288) of graduate alumni and
- 47.5 percent (1,740) of undergraduate alumni of the School of Engineering
- 52.9 percent (264) of Stanford's undergraduate alumni majoring in electrical engineering
- 54.3 percent (540) of undergraduate alumni in computer science
- 33 percent (1,348) of Business School alumni

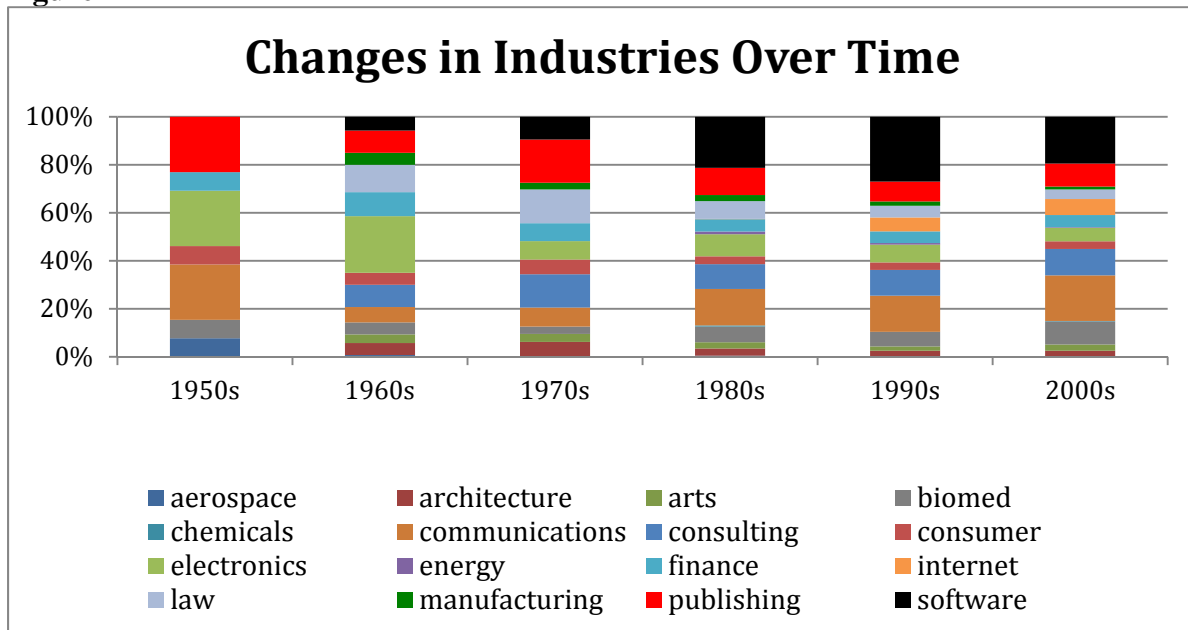
Figure 3



Over the past 50 years, 30 percent of alumni respondents, 22 percent of research staff respondents, and 25 percent of faculty respondents (some of whom are also alumni) founded or incorporated a firm at some point in their careers. These may include an incorporated company, unincorporated business, partnership, informal business, new franchise, non-profit organization, or a purchased company. Founding indicates that the respondent was there at Day 1 and the other cofounders, if any, would consider him/her a founder.

We can see some shifts in the industries that Stanford alumni and affiliates start their companies in over the decades. For firms founded in the 1950s, electronics, communications and publishing were the most common industry categories reported. During the 1990s and the height of the dot-com boom, more than 30 percent of the firms founded were in software or Internet industries with another 14 percent in communications. In the 2000s we can see an increasing interest in energy with the clean-tech trends and over 9 percent of firms are classified as energy related compared to just under 3 percent in the 1970s.

Figure 4



In 2010, 53 of the largest Bay Area companies with a Stanford affiliation generated revenue that accounted for almost 50 percent of the total sales reported by The Silicon Valley 150, an annual list of the region's largest firms, compiled by the San Jose Mercury News.

Table 4 Bay Area Billion Dollar Companies Not Founded By Stanford Alumni

Company	Valuation (\$B)	Revenues (\$B)	Employees
Apple, Inc.	\$395.23	\$108.25	60,400
Oracle	\$142.93	\$35.6	108,429
Intel	\$132.72	\$43.62	96,500
Facebook	\$80	\$4.27	3,000
Applied Materials, Inc.	\$16.32	\$9.55	13,000
Adobe	\$14.84	\$3.8	9,117
Agilent Technologies*	\$14.26	\$4.48	18,500
SanDisk	\$12.58	\$4.8	3,469
Symantec	\$12.24	\$6.19	18,600
Zynga	\$11	\$0.6	3,000
Total	\$832.12	\$221.16	334,015

Listing compiled by the authors, 2012.

*Agilent is an HP spinoff so it could have been considered to be affiliated with Stanford. Agilent was spun out by HP in 1999.

When we looked at high-tech companies in the Bay Area with valuations at or above \$10 billion, we found that companies with a Stanford alum on the founding team (12) outnumbered non-Stanford affiliated companies (10). [See Table 4.] The Stanford-affiliated companies represented 38.6 percent of the total value of all \$10B+ companies, generated 51.5 percent of the revenue and created nearly 60 percent of all jobs associated with this group.

Data Sources: Business Insider, NASDAQ 100, TechCrunch, VentureExpert

Case Example: David Cheriton

Video interview: <http://www.youtube.com/watch?v=NCLiQoPDFjc>

If entrepreneurship is a battlefield of David against Goliath, Stanford professor David Cheriton is battle-tested. Coming to Stanford from Canada was a culture shock for the computer science professor, serial entrepreneur and angel investor who found an exhilarating environment of people working in a university setting, then leaving to launch companies.

Cheriton was interested in finding solutions to “real problems—things that people actually cared about” and also in the “technology transfer process” in which ideas from the lab could be turned into solutions and products for the general public. This didn’t always happen in the research world, he found, where research papers, not products, were often the end result.

Cheriton has had experience moving ideas from academia to commercial reality. In 1995 he and Stanford alumnus Andy Bechtolsheim founded Granite Systems to build Gigabit Ethernet switches. In 1996, Granite was acquired by networking giant Cisco Systems. Five years later, the pair co-founded Kealia, which was acquired by Sun in 2004. Currently, they are working on their third startup, Arista Networks, co-founded in 2004 and a leader in high-speed cloud networking.

To succeed in their many ventures, Cheriton and Bechtolsheim needed to identify both cutting-edge research ideas and market opportunities. Cheriton advises that the entrepreneurial experience is not always linear and the ability to adapt and change is crucial to a market opportunity.

“If you’re David going out into the battlefield with many Goliaths, you don’t want just one slingshot. When you start a company, you have to have at least one good thing going for you, but it’s a lot better to have two or three. You can’t have just one reason to found a company, you have to have several,” he said. “You need to know what the market is doing, the state of the technology, and something about the competition.”

As an example, Cheriton recalls Google creators Larry Page and Sergey Brin coming to him for advice shortly after Granite Systems had been acquired. “Their original interest was in licensing their software.” Cheriton’s advice was that licensing the software was the wrong approach. “I told them, ‘it’s your baby. Unless you raise it, nothing will happen.’ ”

Page and Brin worked on fleshing out their idea and came back a year later asking how they could raise money. He and Bechtolsheim both became early investors. “With Larry and Sergey, we met at the front porch of my house in Palo Alto and at that first meeting, Andy was the first person who wrote a check without any further deliberation. There was no business plan and Google was not even incorporated, but the idea of better search seemed to have potential.”

“I never would have guessed it would grow to this size and this level of success,” Cheriton admits. In fact, at the time it wasn’t even evident to him that it would succeed. A number of companies had tried to be search engine companies, and basically the conclusion was that that was not a business.

Fortunately, Page and Brin ignored that common wisdom. Cheriton said, “I recall some advice I got from a theater instructor years ago. He said ‘whenever anybody comes to me and asks whether they should be in theater, I say no because if they take no for an answer, then they shouldn’t be in theater. If they say screw you I’m going to go there anyway, then at least there’s some hope.’ ”

Starting a business includes responsibility, said Cheriton. “I’ve seen a few companies where they’ve run out of money, they’re shutting down and people have put heart and soul in it. You just don’t go into this lightly. You really have to be committed to making it work. I think that’s the number one element.”

Another great challenge is building a team. The greatest way to reduce the risk is to bring in people you already know and work well with. There is a tremendous value in remembering that as you go through Stanford and use every opportunity to get to know people. I sometimes tell my students that one of the most valuable things you get out of a class is the people you meet in the class.”

Case Example: Andy Bechtolsheim

Video interview: <http://www.youtube.com/watch?v=gubmUIZI35Q>

Andy Bechtolsheim has a keen eye for market opportunities and a focus on product development that led him to co-found Sun Microsystems in 1982 and become the first investor in Google. This same sharp sense and understanding of the connection between the business and the technology served him throughout his various entrepreneurial and venture capital investments.

In the summer of 1977, as a 21-year-old graduate student at Carnegie Mellon University, Bechtolsheim drove his Volkswagen Rabbit to Silicon Valley for a summer internship at Intel. By the time he arrived, his mentor at Intel had transferred to Oregon, but he decided to stay in Silicon Valley and started hanging out at Stanford, where he saw an advertisement for a job to help a professor with CAD (Computer Aided Design) programming. He spent the summer programming and in the fall was invited to continue on as a PhD student.

Bechtolsheim quickly realized that Computer Aided Design required a lot more horsepower than what was available from time-shared mainframe computers. At the same time he held the CAD job, Bechtolsheim worked as a no-fee consultant at Xerox PARC, which had invented the Alto, the first networked workstation computer. This experience inspired him to design the SUN workstation, named after the Stanford University Network (SUN) project, which subsequently became the origin of Sun Microsystems.

Founded in 1982, Sun Microsystems went public four years later. Sun was one of the fastest growing computer companies of the 1980s and 1990s, achieving over \$1B in revenue within five years.

None of this was foreseen when Bechtolsheim was a graduate student putting together the design of the Sun workstation in the basement of Margaret Jacks Hall. There were competing projects to build microprocessor-based workstations MIT and Carnegie Mellon, and at least five other startup companies competing in the same field. How did Sun succeed where all others failed? Bechtolsheim cites three critical differences.

First, given the Stanford and Silicon Valley location, Sun was able to attract significant venture funding from local venture firms. Bechtolsheim recalls venture capitalists “hanging out at Stanford” to find interesting ideas. There was a perception among the VCs that, on average, Stanford startups had higher odds of success.

Second, during the development of the Sun workstation at Stanford, Bechtolsheim was able to freely to interact with potential users, customers and even future competitors. The feedback we got regarding the early prototypes, he feels was crucial to perfect the thing I was working on.”

Third, and the most critical difference, he believes, was the founding team. Vinod Khosla, a graduate of Stanford’s Graduate School of Business, contacted Bechtolsheim in early 1982. Khosla saw a clear market opportunity for general purpose workstations. Scott McNealy, Khosla’s business school classmate, joined initially as Director of Operations and finally Bill Joy joined as the software guru, having developed the next-generation version of Unix at UC Berkeley. Bechtolsheim remembers, “we went from writing a five-page business plan to receiving venture funding to incorporating Sun in four weeks, shipped the first product three months later and were cash-flow positive within six months.”

Sun grew very quickly during the 1980s and 1990s, first dominating the Unix workstation business and then the Unix server business. With integrated networking and the marketing slogan

“The Network is the Computer” Sun became the leader in client-server computing and played a key role in the commercialization of the Internet in the 1990s.

“Everybody had to be online, everybody wanted a browser, a website. Sun did extremely well in the 1990s ... but then missed the transition to the next-generation technology and ended up losing the market share battle. The real winners were the new companies that defined new business models and took advantage of the new opportunities around the Internet,” Bechtolsheim said.

In 1995 Bechtolsheim left Sun to pursue a networking opportunity around Gigabit Ethernet. Together with Stanford Professor David Cheriton and a few of his students, he started a new company called Granite Systems, which developed a low-cost Gigabit Ethernet switch design. Granite was acquired shortly later by Cisco for \$220 million and Bechtolsheim continued with Cisco as the General Manager of the Gigabit System Business Unit. In 2004, he returned to Sun when Kealia, another start-up he co-founded with David Cheriton, was acquired by Sun. He once more left Sun in 2008 and is currently in charge of development at Arista Networks, another start-up he co-founded with David Cheriton.

When we asked Bechtolsheim whether taking on risks was part of the reason for his successes, he instead offered: “Risk is the wrong word. To me, Sun was a zero-risk startup because I knew there was a large market opportunity for this product. It was just about getting it out the door and selling it. Quite frankly, good startups don’t take on a lot of risk. They focus on making the right technology choices and product investments to go after significant market opportunities. If you build the right product at the right time for the right market, success is much more predictable. That’s true even today.”

Bechtolsheim’s keen ability to understand both the technology and the market it fits into has helped him not only identify market opportunities for start-ups, but also to identify investment opportunities. Over time, he has been on the board of more than 25 companies, with the majority going public or being acquired. His secret? “The key is to understand the technology, the market opportunity, and the competitive dynamics specific to this opportunity. This generally defines the outcome.”

He met Larry Page and Sergey Brin through Cheriton, and saw an early version of what would become the Google search engine. The page rank approach to search results made sense to Bechtolsheim. “It was immediately obvious to me that this is the right way of solving the problem and I trusted that they could build the data structures behind it,” he recalled.

The next question was the business model. Could sponsored ads next to the relevant search results make money at \$0.05 cents per click? “I made this quick calculation in the back of my head which was if they get a million clicks a day at \$0.05, that’s \$50K a day, which means they should be able to get to breakeven quickly.”

At the time, Page and Brin were considering licensing the technology, which Bechtolsheim reasoned would have completely missed the opportunity. “My contribution to Google, which at the time wasn’t incorporated yet, was to actually get them going. I made the check out to Google, Inc. which didn’t even exist.” The check was for \$100,000 and the rest, as they say, is history.

Different companies need very different amounts of funding. Some companies can be started on a few hundred thousands of dollars that are often raised from angel investors. For example, iPhone app companies tend to fall into this category. Most startup companies need millions or tens of millions of dollars, which are usually provided through VC funding. Then there are the

capital-intensive companies, such as green technology, that need hundreds of millions of dollars, requiring funding sources beyond traditional venture capital. “Some of the best startups are the ones that require the least amount of funding,” says Bechtolsheim. “The faster a startup can get to break-even, the more attractive it is from a return-on-investment standpoint.”

Bechtolsheim’s advice for Stanford students: “Take advantage of your time while a student to understand the various opportunities in front of you, before committing to any particular direction.”

THE BASES STUDY

In addition to the 2011 Alumni Innovation survey, another survey was done by the student-run Business Association of Stanford Entrepreneurial Studies (BASES) in conjunction with two corporate partners: Quid and Samsung. The mission of BASES is to promote entrepreneurship education at Stanford and to empower the next generation of entrepreneurs.

The BASES study identified startups founded by BASES alumni within the past 10 years. Founders needed to be involved with BASES within five years of founding their company. The latter stipulation was used to increase the likelihood that they identified the founders that may have developed business ideas while at Stanford and to identify the progress of the newest wave of Stanford and BASES entrepreneurs.

The study identified 173 startups founded by Stanford BASES alumni. For the purposes of this BASES project “alumni” is defined as any person who attended or worked for Stanford and was involved in BASES and includes both undergraduates and graduates plus students who attended but did not graduate from their program.

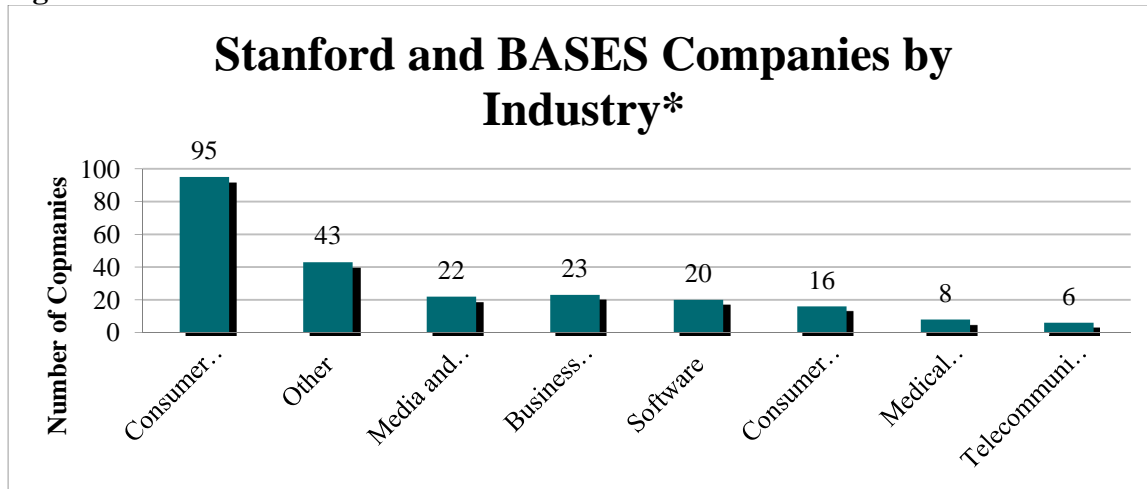
To qualify, companies must meet all of the following criteria:

- Less than 10 years old;
- Founded or co-founded by a BASES alumni;
- Still in operation, merged, or acquired (not out of business)
- Scalable business with technology-centric product or service.
- Founded company while part of Stanford or BASES or within five years of leaving Stanford

Figure 5

Consumer Finance	Video
1. KaChing	1. Huddler
2. 2.Bills.com (Freedom Financial Network)	2. ooyala
	3. BrightRoll
	4. Omnisio
Real Estate	5. VideoGenie
1. Redfin	6. Adap.tv
2. Trulia	7. BestTV
Facebook/Social Network add-ons	Dating
1. LOLapps	1. SeedDate.com
2. Sharethrough (formerly 750 Industries)	2. OkCupid
3. Context Optional	
4. Bippy	

Figure 6



Consumer Internet is the most popular industry for Stanford and BASES entrepreneurs. The study found 48 percent of companies founded by Stanford alumni and 48 percent of companies founded by BASES alumni were consumer Internet companies. Some of the most popular sectors are social networks, e-commerce sites, and video sites.⁹ Some company founders highlighted the strength of Stanford’s Computer Science courses which help entrepreneurs gain the skills they need to create dynamic websites.

Funding Startup Businesses

Stanford University does not collect, track or maintain information about funding as part of its general entrepreneurship programs. Some universities invest directly in startups created by their faculty and students. Stanford does not have this kind of institutional incubator, although some investments are made in companies that have licensed Stanford technology (See Page 81).

Extrapolating from data provided by 2011 Stanford Innovation Survey respondents, \$88 billion in funds are estimated to have been raised by 11,565 companies founded by Stanford alumni who graduated after 1990.

For firms founded by graduates from the past two decades, respondents estimated \$3.5 million on average was raised in external funding for each Stanford-affiliated non-bioscience

⁹ Note: Companies can have more than one industry categorization. The table above shows all industry categorizations.

* “Other” contains multiple industries. No industry contained more than five companies. These industries include biotechnology, clean technology, networking and equipment, semiconductors, and health services.

startup from a number of sources: Almost 9 percent (972 firms) received venture capital funding; more than 10 percent (1,104 firms) received funding from angel investors; almost 4 percent had foundation funding, and some 5 percent received other types of funding.

Figure 7

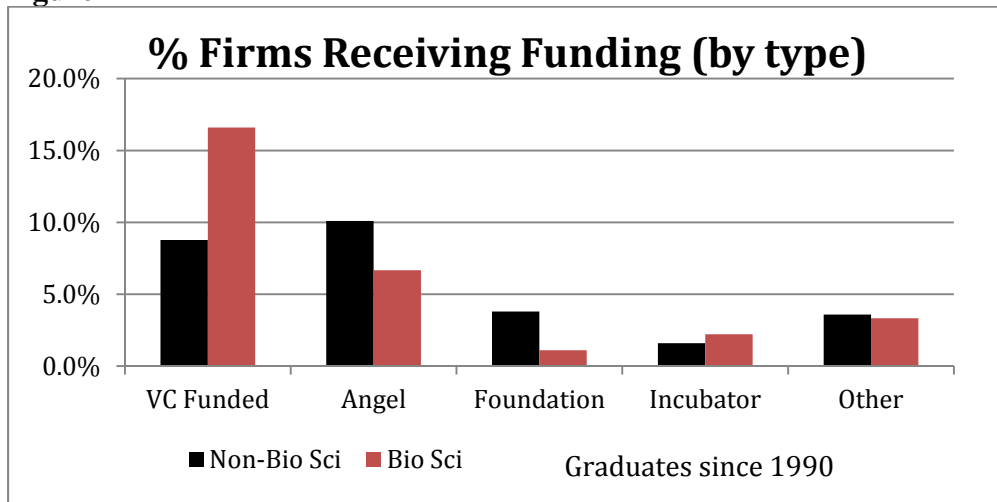


Figure 8

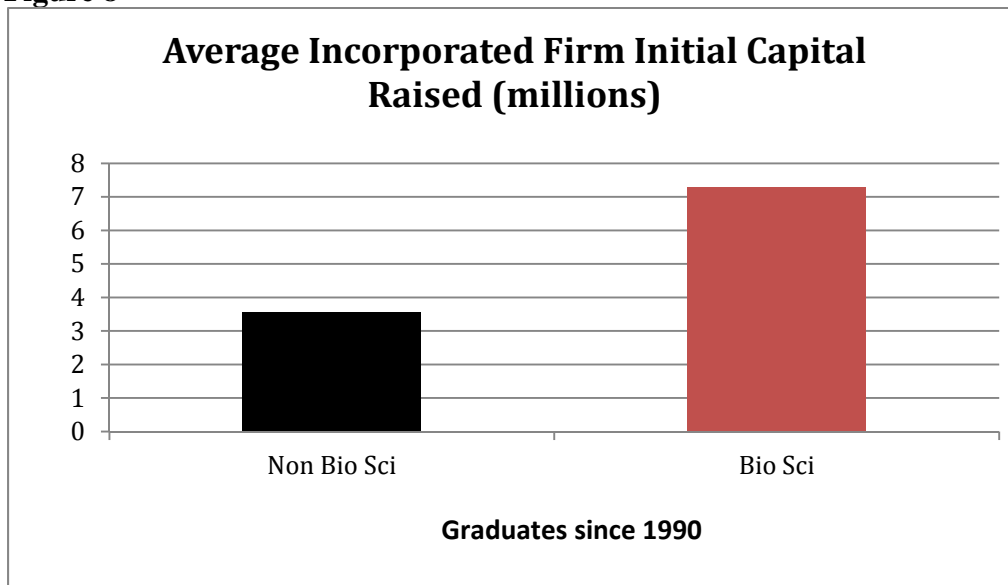


Figure 11

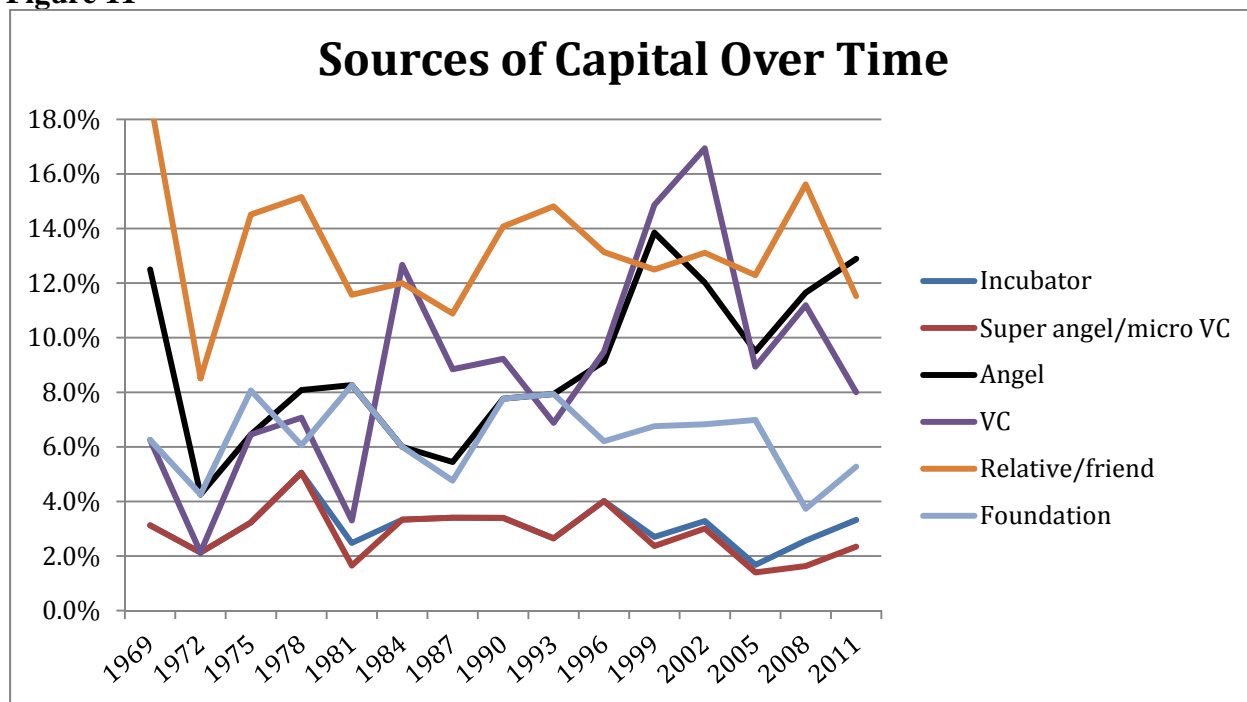


Figure 11 above comprises data from 3,335 funding rounds. Self-funding is the most common source, comprising between 50 to 60 percent of the funding rounds consistently over time. After self-funding, relatives and friends are the next most frequent source of startup capital. We see that along with funding from foundations, incubators and so-called super angels or micro venture capital funds, these sources of funding are relatively stable over time. Despite claims by many of an increase in certain sources (i.e. angels or incubators), we do not see widespread evidence of this, though it may be true in certain industries or sectors within software. The terms incubator, accelerator, super angel, and micro VC are new, but in retrospect, many of our entrepreneurs reported having received funding from what they now would label as these types of sources. However, VC and traditional angel funding are more cyclical, and we see them increasing during the dot-com bubble and falling post-2001. We can also see the rapid increase in venture capital as a source of financing after the 1978 reform allowing pensions to invest in private equity. Angel funding surged in the most recent (2009-2011) time period when VC continued to decline.

One interesting question is whether there is a higher or lower return on venture capital investments in Silicon Valley compared with other regions. It could be that competition for hot deals (startups) in Silicon Valley drives up the valuations and thus drives down the returns for the VCs. If talent was fairly equally spread geographically, it could feasibly be a better strategy to look for the less hyped deals that others are not fighting over. Besides the data that coauthors and I have collected from MIT (Roberts and Eesley, 2011) and Stanford alumni, two other papers came to mind.

Professor Robert Hall, the Robert and Carole McNeil Joint Professor of Economics and Senior Fellow at the Hoover Institution at Stanford University and Susan Woodward, former Chief Economist of the U.S. Securities and Exchange Commission and Chief Economist of the

U.S. Department of Housing and Urban Development, have written one of the most thorough recent examinations of the returns to venture capital and VC-backed entrepreneurs¹⁰. However, it did not address the issue of geography. The other paper does address geography directly. Chen and coauthors (2010)¹¹ find that defining success as the proportion of portfolio companies that go public (IPO), VCs in Silicon Valley, New York and Boston have greater performance and their VC-backed companies in those locations also have higher performance. However, the outperformance of these VC firms comes more from selecting better investments when they invest outside of Silicon Valley, Boston and New York City. If you are a top entrepreneur outside of one of these startup hubs and a major Silicon Valley VC as well as a local VC both give you term sheets, it's going to be very tempting to take the Silicon Valley VC's term sheet.

However, this still did not answer the direct question of whether Silicon Valley firms outperform those in say Boston or New York City. It also only looks at IPO rates rather than at revenues or employees as alternative performance measures.

For this, we examined the data from the Stanford Innovation Survey. We find that the Silicon Valley firms (defined as those located 60 miles or less from Stanford) have statistically significantly higher revenues and employees relative to those not in Silicon Valley. [\$128M in mean revenues vs. \$62M, $p < 0.05$]

Yet, when you compare Silicon Valley firms against those in Boston or New York, there are no significant differences in revenues or employees. It is worth noting that the Silicon Valley firms are bigger on average (the distributions are highly skewed), yet this difference is not statistically significant. [\$128M vs. \$29M, $p < 0.17$ and 307 employees vs. 51 on average, $p < 0.27$]. Since these distributions are so skewed, the median is perhaps more informative [\$300,000 vs. \$150,000].

Finally, we looked at the current status of the firms. For Silicon Valley firms, the breakdown looks like this: Private firm: 55 percent, Acquired: 23 percent, Out of business: 18.4 percent, IPO: 4.2 percent. For MA and NYC: Private firm: 67 percent, Acquired: 15.5 percent, Out of business: 16.5 percent, IPO: 2 percent. It appears that the Silicon Valley firms have a higher rate of IPOs and acquisitions compared with the MA and NYC firms.

Stanford alumni respondents who described themselves as angel investors said they have collectively invested \$9.2 billion in private entrepreneurial companies since graduation. Alumni venture capital investors have been responsible for investing \$95 billion collectively over the course of their investing careers in private entrepreneurial firms.

As an example of the impact of venture capital funding on the Stanford entrepreneurial ecosystem, take the case of Sequoia Capital, founded by Don Valentine in 1972, which has financed many Stanford alumni ventures, including many that have had a major impact on Silicon Valley. Below, we show some of the firms financed by Sequoia that were either founded by or had key early employees and executives from Stanford.

Table 5 Sequoia-backed firms with Stanford founders

Company	Valuation (\$B)	Stanford (co)Founder
Nvidia	\$10	Jen-Hsun Huang

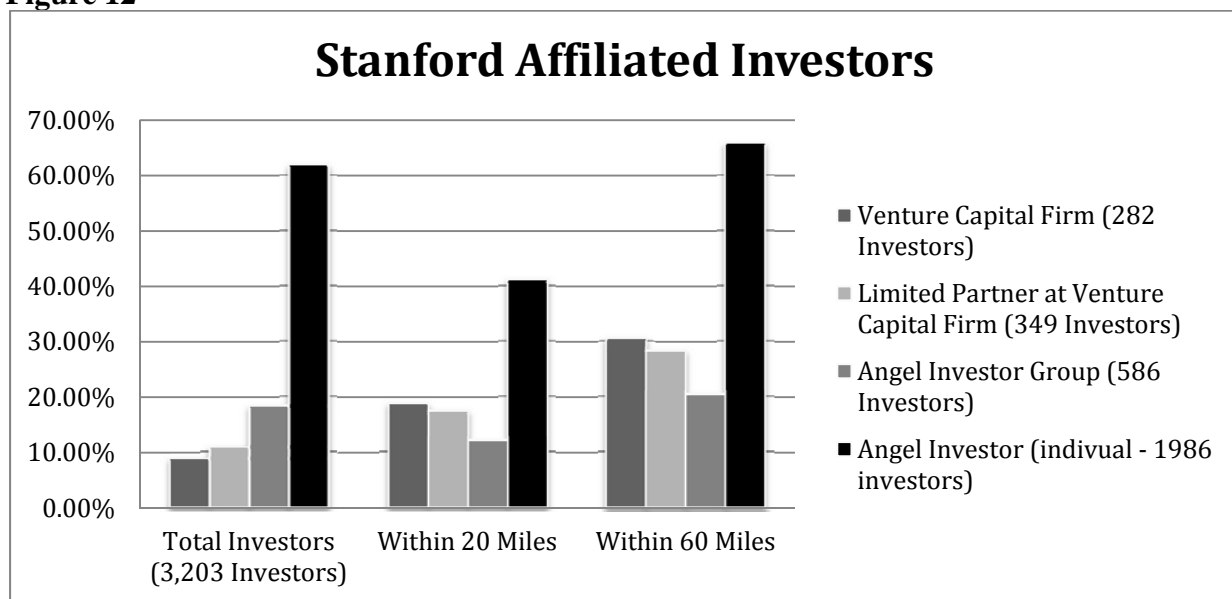
¹⁰ The Incentives to Start New Companies: Evidence from Venture Capital. NBER Working Paper No. 13056.

¹¹ Buy local? The geography of venture capital. *Journal of Urban Economics*.

NetApp	\$18	1) James Lau; 2) Michael Malcolm
Yahoo!	\$20	1) Jerry Yang; 2) David Filo
Google	\$189	1) Sergey Brin; 2) Larry Page
Cisco	\$94	1) Leonard Bosack; 2) Sandra Lerner
Octel Communications	\$1.8	Bob Cohn
Plaxo	\$0.175	1) Todd Masonis; 2) Cameron Ring
Stella & Dot	\$0.37	Jessica Herrin
Meebo	\$0.25	1) Elaine Wherry; 2) Sandy Jen; 3) Seth Sternberg
Jawbone	\$1	Hosain Rahman
Youtube	\$1.6	Jawed Karim
First Republic	\$3.8	Katherine August-DeWilde
Aster Data	\$0.26	Mayank Bawa
Trulia	\$0.2	1) Peter Flint; 2) Sami Inkinen
Loopt	\$0.25	Sam Altman
Paypal	\$1.5	Peter Thiel
Cypress	\$2.9	TJ Rodgers

STUDY OF INVESTORS

Figure 12



- The BASES study of investors showed that several work closely with Stanford startups. The investors include traditional venture capital firms, as well as seed accelerators (e.g. Y Combinator and fbFund Rev) and angel investors (Ron Conway). Some 98 startups in the study received funding, meaning that the top investors each worked with 7-9 percent of all known startups that received funding. This indicates a high involvement between Stanford/BASES alumni and investors.

The BASES study of alumni startups also produced information on sources of funding for companies started by Stanford alumni of that program.

Investors	Number of Companies	Company Names (Investment Recipients)
Draper Fisher Jurvetson	9	Infoaxe, BinOptics, Increo Solutions, ooma, 4INFO, D.light Design, Redfin, RichRelevance, and meebo
Accel Partners	8	AutoQuake, Cloudera, Trulia, SunRun, Infinera, Medio Systems, Kosmix, and Medio Systems
Ron Conway	7	Aster Data Systems, LOLapps, Sharethrough (formerly 750 Industries), Wambo (Perenety), PBworks (formerly PBwiki), Blippy, and Posterous
Sequoia Capital	7	Onetta, Blippy, meebo, Trulia, SunRun, Aster Data Systems, and Loopt
Y Combinator	6	Jamglue, Crystalroot, Nowmov, Posterous, Loopt, and Omnisio
Mohr Davidow Ventures	5	hi5 Networks, Medio Systems, PBworks (formerly PBwiki), Nanosolar, and RingCube Technologies
Greylock Partners	4	Cloudera, Progreso Financiero, RichRelevance, and Redfin
Benchmark Capital	4	Kosmix, kaChing, Cooliris, Coverity, and Progreso Financiero
DAG Ventures	4	Kosmix, kaChing, Cooliris, and Progreso Financiero
fbFund Rev	4	GroupCard, Gameyola Games, Socialfly, and FriendFit
JAFCO Ventures	4	Voltage Security, Infinera, meebo, and Aster Data Systems
New Enterprise Associates (NEA)	4	Huddler, Tableau Software, RingCube Technologies, and Loopt

ALUMNI INITIATIVES: STANFORD ANGELS & ENTREPRENEURS ALUMNI GROUP

Created in 2011, Stanford Angels & Entrepreneurs (SA&E) is an official Stanford University Alumni Association organization fostering relationships between potential entrepreneurs and investors. The alumni-driven organization provides networking and funding opportunities for students, alumni and startups plus educational programs to both angels and entrepreneurs.

- SA&E seeks to connect angel investors to entrepreneurs building scalable companies of significance and to connect entrepreneurs with sources of capital, mentorship, prospective team members, peer-to-peer networking and insightful, supportive feedback.
- SA&E seeks to encourage a diverse group of people to consider entrepreneurship and angel investing and to that end, provide education on entrepreneurship and early-stage investing as well as opportunities to meet role models.

Figure 12

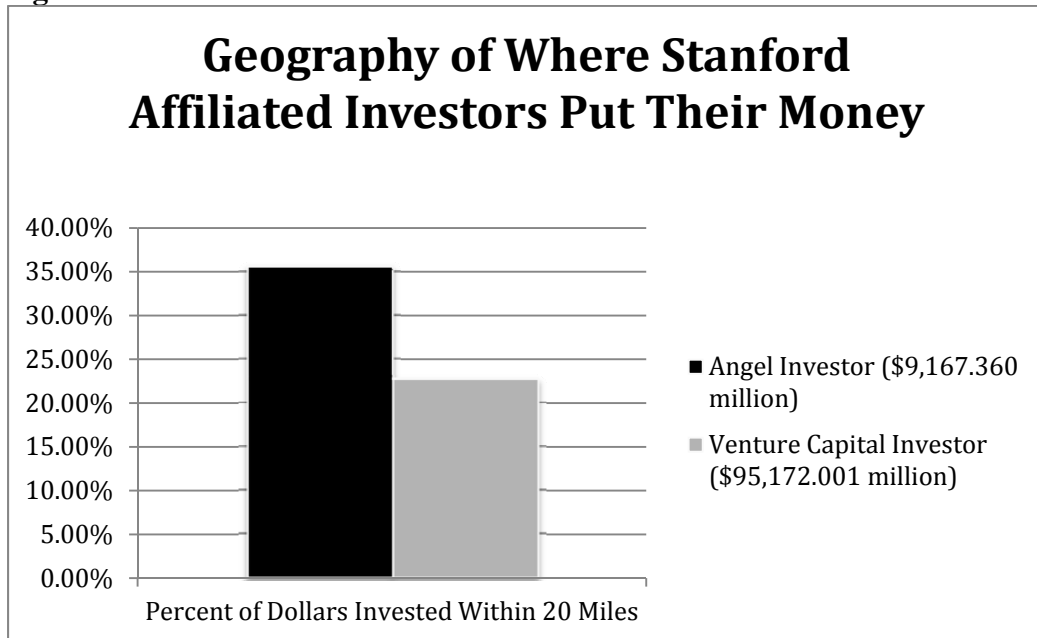
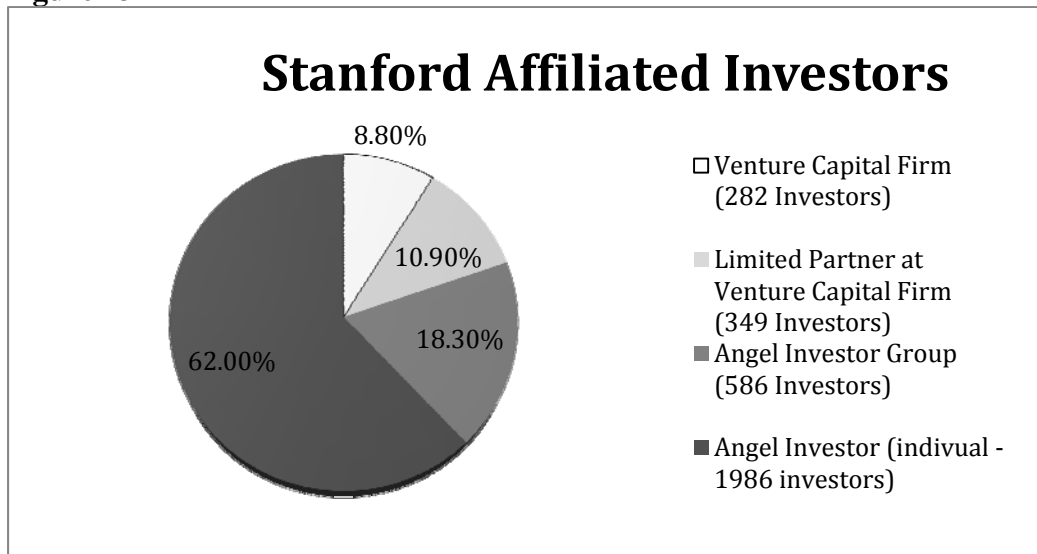


Figure 13



CASE EXAMPLE: CLINT KORVER

Clint Korver came to Stanford for graduate school because of its proximity to Silicon Valley. After earning a PhD in decision analysis through the Engineering and Economic Systems program (now part of Management Science & Engineering) at Stanford he went on to found four companies. Then he discovered he loved being an angel investor.

Korver came from a family of entrepreneurs. His father was a small businessman and his mother ran a store. His great grandfather repaired shoes and leather saddles. At Stanford he began discovering the method that made entrepreneurship possible through School of

Engineering classes in technology entrepreneurship. He wrote a business plan for a class assignment with the idea to implement it upon graduation. Korver vowed to succeed in approximately the same time it took his former work colleagues to be promoted to partner in their firms. This motivated him to finish his dissertation in what he recalls were the three most productive months of his life.

Korver started his first company in 1994, applying decision analysis in bank lending. He went on to start four firms, all applying decision analysis in different ways. In 1998 he raised venture funding for a fifth company, but decided to return the funds when he realized he didn't have the "killer idea".

While considering his next venture he decided to do some angel investing and found that he loved it. In startups, he was good at going from nothing to the first \$1 million, but at that stage, it was less about building the team and more about putting in a set of processes. Early-stage investing was what he loved—the undefined part of things. Korver began talking to other angel groups but none were investing in the way he wanted to, which was very systematic and professional. He found that he aligned a lot more with venture capitalists, so he joined Crescendo Ventures as a venture partner, initially on a volunteer basis. His pitch to them was to be allowed to hang around and learn venture investing and in return he offered to show them the decision analysis techniques he was using. He began to apply all the decision analysis technology to investing in startups, which is very different from typical VC due diligence. It took a lot of effort and time, but it was basically the lessons he had learned as a student from Professor Ron Howard, applied to venture capital.

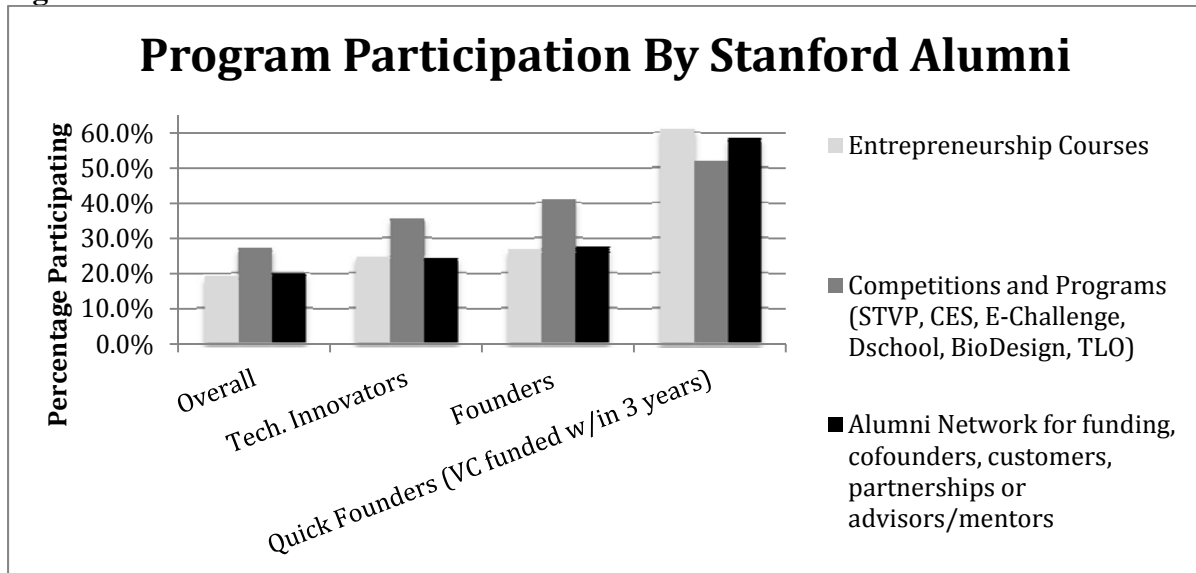
With a nod to the group called the Harvard Business School Angels, Korver and Miriam Rivera launched Stanford Angels & Entrepreneurs in November 2010 as part of the Stanford Alumni Association. The launch event drew 250 people including Jerry Yang (Yahoo) and Diane Greene (VMWare). So far the group has held a dozen events including five or six pitch events. Ninety percent of the attendees and participants have been Stanford alumni. They've made seven investments ranging from \$25K to \$800K collectively. The group does the screening, coordinates pitches, and due diligence, but everyone invests as an individual.

When asked what advice he would give to current Stanford students, Korver said, "Students should be mindful of the initial path that they take out of school. It is easy to get trapped by your success, making it harder to make a risky career change later."

How Stanford's Academic Experience Creates Entrepreneurs

In the 2011 Stanford Innovation Survey, we asked participants about their classroom experience at Stanford to see if any patterns emerged. We found that successful entrepreneurs were more likely to have taken part in some programs and classes that helped shape their future careers.

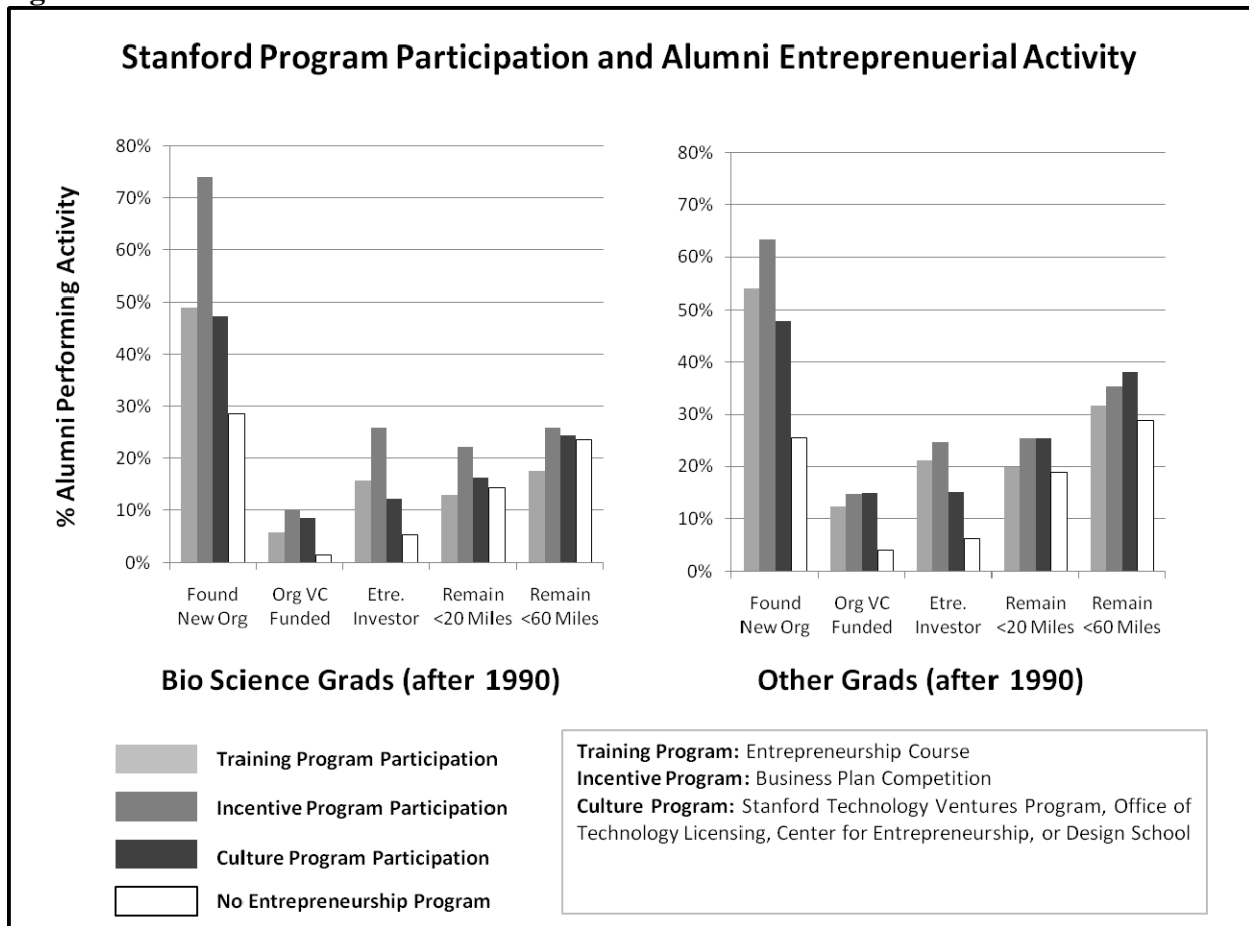
Figure 14



According to respondents, technical innovators—those who created new products, production process or business models—and entrepreneurs were more likely than other alumni to have participated in entrepreneurship courses and programs.

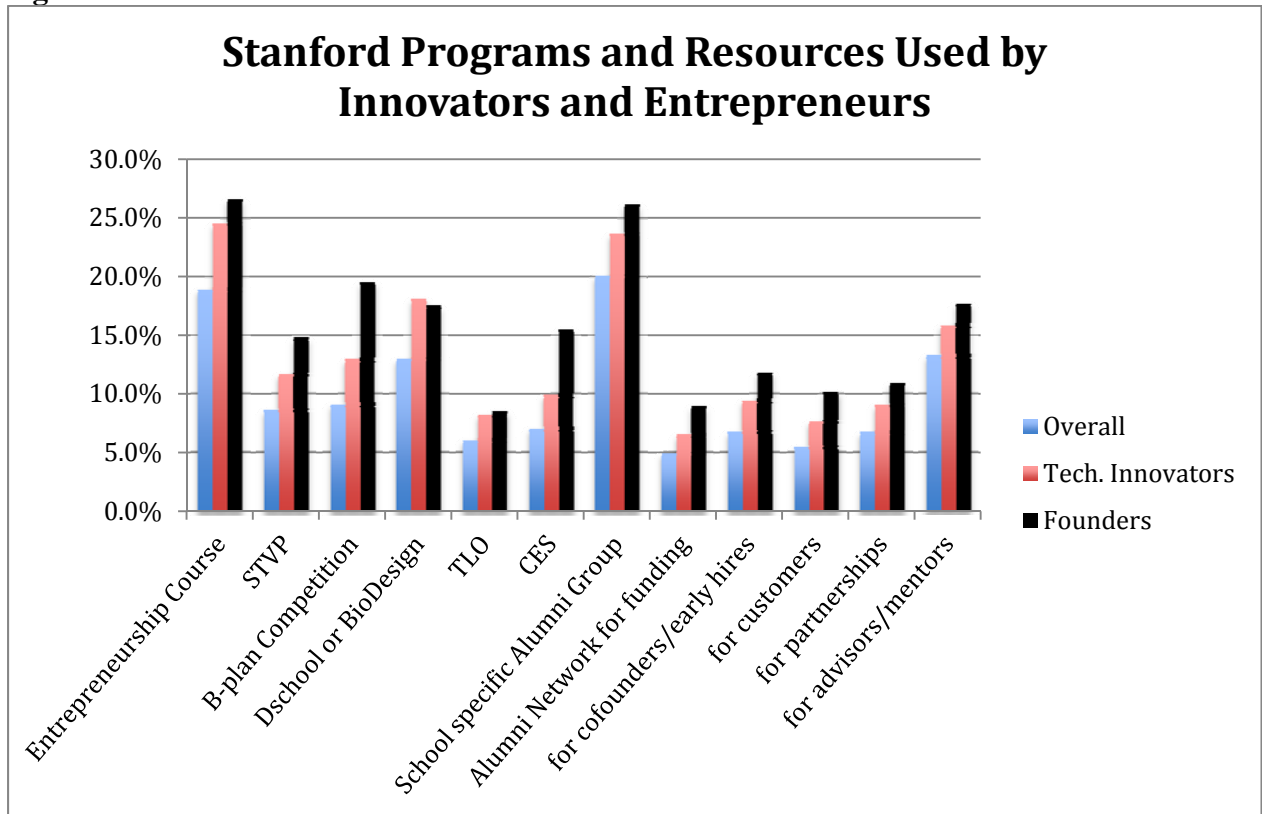
- Approximately 25 percent of the technical innovators and founders took an entrepreneurship course at Stanford, as did 60 percent of the “quick founders”—those who received VC funding within three years.
- The percentages that engaged in competitions and programs were even higher:
 - 35 percent of technical innovators,
 - 40 percent of founders and
 - Over 50 percent of quick founders participated in E-Challenge, Stanford Technology Ventures Program, Center for Entrepreneurial Studies, d.school or other entrepreneurship programs.
 - All three categories of innovators were also much more likely to have used the alumni network, particularly for identifying funding sources, cofounders, early hires and mentors.

Figure 14



Overall the incentive and cultural programs are associated with a 30-to-50 percent increase in the likelihood of founding a firm within the immediate area. For the bioscience grads, the incentive programs are associated with the largest effect — they are 55 percent more likely to remain in the area if they participated in these programs. Alternatively, it could also be that these data show the demand for these courses by students who already plan to be entrepreneurs. While it is not clear which it is, the data certainly shows the demand for these entrepreneurship courses and programs.

Figure 15



- Tech. innovators are defined as those alumni who created patents, new products, new production processes, or new business models)
- Entrepreneurs and technology innovators were:
 - More likely to have participated in entrepreneurship courses, Stanford Technology Ventures Program, Center for Entrepreneurial Studies, business plan competition, d.school
 - More likely to have used the alumni network, particularly for funding, cofounders, early hires, and mentors.

These aspects of the Stanford environment appear to have been especially important for them.

Table 6: Role of Stanford

	Overall	Tech. Innovators	Founders
Worked with Faculty	67.9%	68.2%	65.5%
Entrepreneurship Course	18.9%	24.5%	26.7%
Stanford Tech. Ventures Program	8.7%	11.7%	14.8%
Research	57.6%	57.4%	54.5%
Student Groups	62.9%	63.1%	62.3%
International Study Abroad	20.7%	19.0%	20.3%
B-plan Competition	9.1%	12.9%	19.5%
d.School or BioDesign	13.0%	18.1%	17.5%
TLO	6.0%	8.2%	8.5%
Center for Entrep. Studies (GSB)	7.0%	9.9%	15.5%
SAA	61.4%	64.5%	65.6%
Alumni Regional Club	34.4%	36.4%	38.7%
School specific alumni group	20.1%	23.7%	26.2%
Alumni network for funding	4.9%	6.5%	8.9%
for cofounders/early hires	6.8%	9.4%	11.8%
for customers	5.5%	7.7%	10.2%
for partnerships	6.7%	9.1%	10.9%
for advisors/mentors	13.3%	15.9%	17.7%
School Career Center	37.7%	39.1%	34.2%

- Only graduates after the year when the program was created were included in the analysis (i.e. STVP created in 1996, so only graduates from 1996-2010 were included).
- Participation as a student, alumni, or faculty/staff member was merged together.
- Participation marked as “a little”, “moderate”, and “heavy participation” were merged.

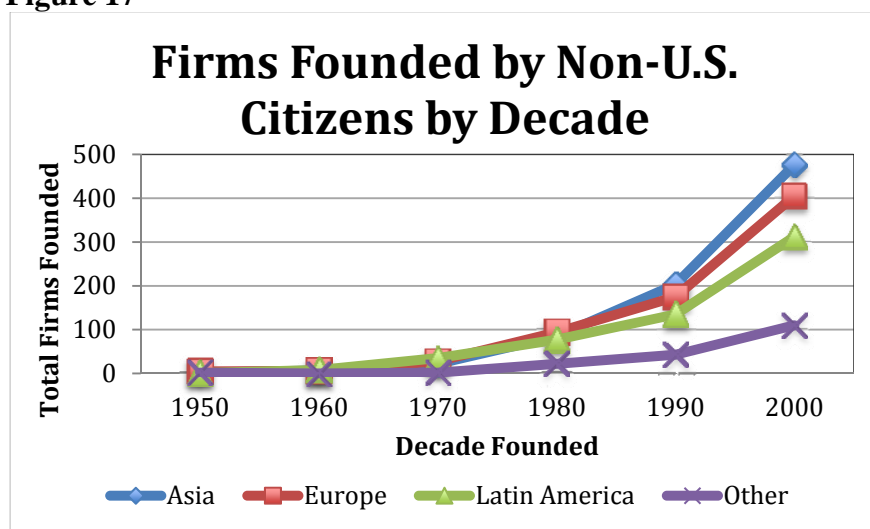
Table 7: Among alumni entrepreneurs

Entrepreneurship Courses Mentioned by Alumni	Percentage	Estimated Total Number of Alumni Influenced
Management Science and Engineering	17.1%	1855
GSB course	16.8%	1825
Professor Irv Grousbeck	6.3%	684
E145 Technology Entrepreneurship (Tom Byers, Steve Blank, Tom Kosnik)	4.8%	523
Design (anything)	3.1%	331
BioDesign	2.8%	309
Social Innovation	2.6%	287
Entrepreneurial Thought Leaders	2.4%	265
Engineering (Electrical, Mechanical, etc.)	2.4%	258
Tech. Venture Formation (273, Michael Lyons)	2.0%	213
Managing Growing Enterprises - Dirk Allen	1.8%	199
Professor Tom Kosnik	1.6%	177
Mayfield Fellows	1.3%	140
Professor Steve Brandt	1.2%	125
Other	35.7%	3878
Total	100.0%	10855

Changing Patterns in Entrepreneurial Career Paths

More Diverse Entrepreneurs: We broke down the nationality of the non-domestic Stanford-affiliated founding members and noted a universally accelerating trend across all regions of the world (Figure 17). In the 2000s the largest proportion of non-U.S. national founders came from Asia, comprising nearly 8 percent of all company founders and 41 percent of all non-U.S. founders. Europe accounted for 6 percent of all founders and 31 percent of all non-U.S. founders and Latin America represented 4 percent of all founders and 20 percent of non-domestic founders. Countries that lie outside these three main regions (excluding the United States) represent 1.4 percent of the total founding populations and 7.5 percent of all non-domestic Stanford entrepreneurs. Despite differences in proportions across regions of origins, the number of entrepreneurs coming out of Stanford and founding firms has increased at a rapid rate over the last 50 years and appears that it will continue to do so.

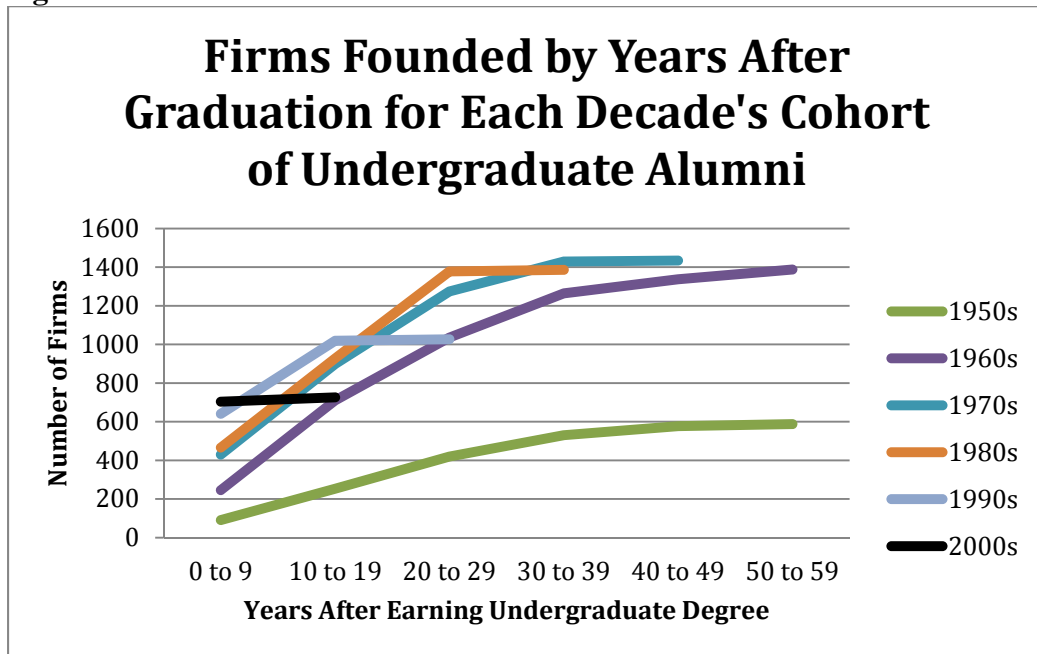
Figure 17



Since 1984, nearly 44 percent of Stanford's graduate students have come from outside the United States. Response to Stanford's Innovation Survey indicate that 15 percent (2,600) of graduate students from outside the U.S. have stayed in the Bay Area and contribute to the region's robust infrastructure and entrepreneurial spirit.

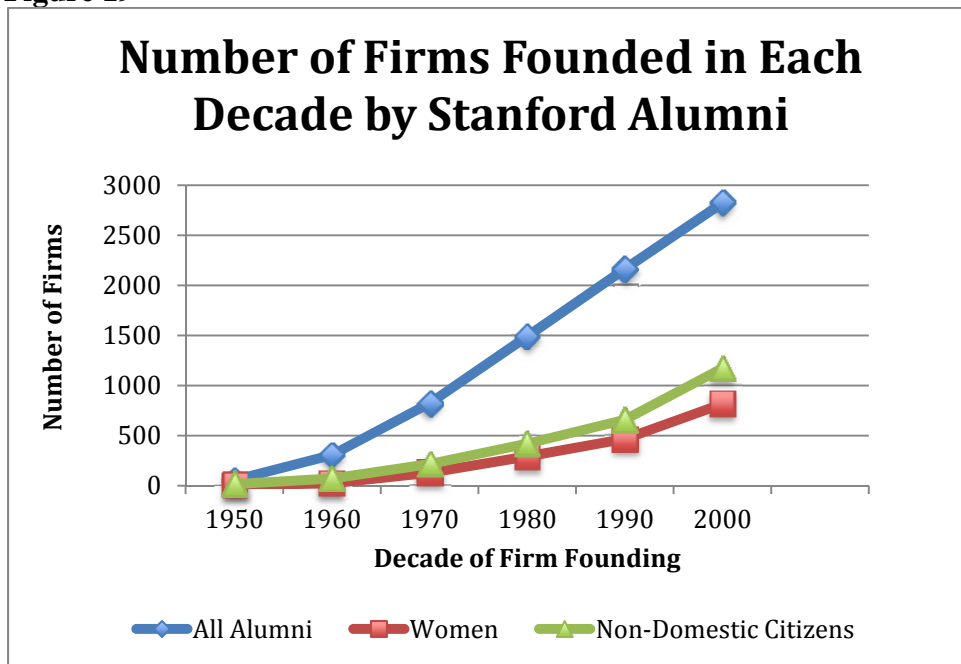
Younger Entrepreneurs: More entrepreneurs emerge out of each successive Stanford graduating class, and they start their first companies sooner and at earlier ages. (See Figure 18) During each successive decade, the cohort of graduating alumni began its entrepreneurial behavior earlier (i.e., the cumulative number of companies rises much faster in terms of years after graduation) than the preceding decade's cohort. This trend holds true for most of the data before the 2000s. This can most likely be attributed to the recession that was experienced after the dotcom bubble burst. Despite various outside factors, we still see that the total number of firms founded by each successive graduating cohort rises and that more and more of Stanford's alumni are taking the entrepreneurial route.

Figure 18



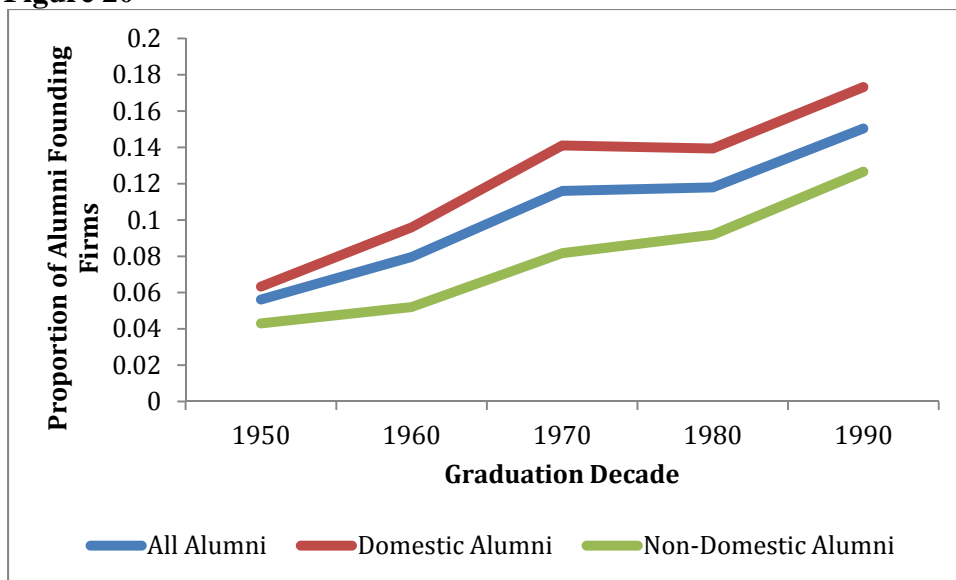
More Entrepreneurs Emerging Sooner: Figure 19 shows the estimated yearly growth over the past 50 years of first-time firm formation by Stanford alumni entrepreneurs. Overall, we see an increasing trend of new firm formations throughout the decades. Of the responding population, non-U.S. citizens accounted for 29 percent of new firms in the 1950s; and this proportion held steady into the 1990s, with 30 percent of the new firms being founded by non-U.S. citizens. In the 2000s, there was an increase in non-U.S. alumni founding firms, raising the representative proportion to nearly 42 percent. Similarly, women comprised 5 percent of the entrepreneurial population coming out of Stanford in the 1950s, but rose to 21 percent in the 1990s and nearly 29 percent in the 2000s. As the number of firms founded each decade by Stanford alumni continues to grow, we are seeing an increasing number of women and non-domestic alumni relative to the total populations, indicating a growth in diversity among Stanford-affiliated entrepreneurs.

Figure 19



Some 5,556 firms were founded by students while still at Stanford or within a year of graduation.

Figure 20

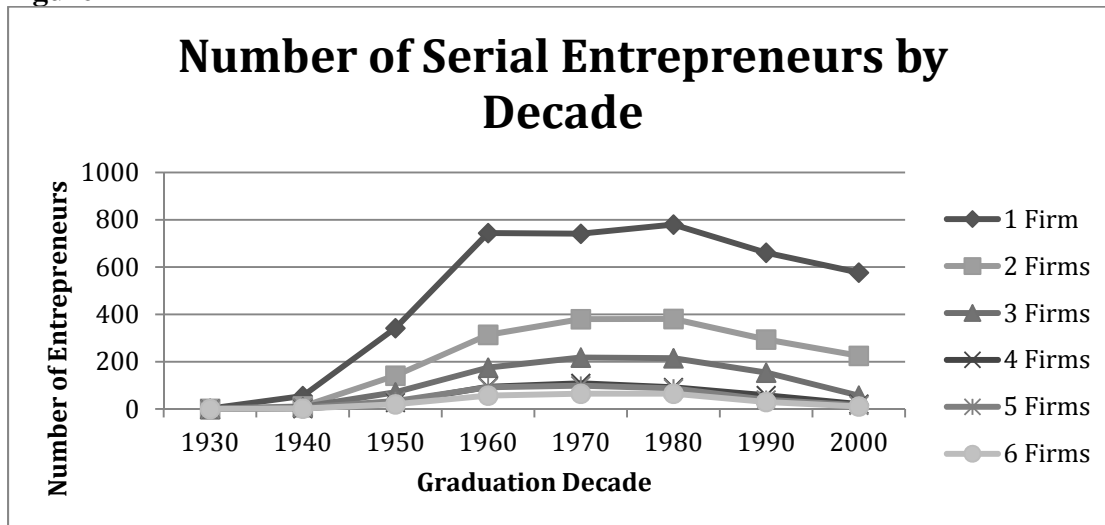


When we limit the proportion of alumni founding firms in each graduate decade to the ten years immediately following graduation, we can see an increase in the overall proportion of alumni founding firms as well as both the domestic and non-U.S. alumni populations. We limited this analysis to the ten years following graduation to allow for each decade's graduating cohort to have an equal timeframe post-graduation to found firms. We can see that the overall proportion

of alumni founding firms increased from 6 percent in 1950 to nearly 15 percent in 1990. Similarly, we see the proportion of domestic alumni increasing from 6 percent to nearly 17 percent and the proportion of non-domestic alumni increasing from 4 percent in 1950 to 13 percent in 1990.

Serial Entrepreneurs:. Serial entrepreneurs, those who found more than one business, create a disproportionate share of both entrepreneurial firms and economic impact (Roberts and Eesley, 2009). Correspondingly, serial entrepreneurs create a high proportion of jobs and economic growth relative to the larger number of novice or one-time only ones. Below we see the number of entrepreneurs graduating in each decade and each line represents the number of first firms, second firms, third firms, and so on that they have created. We see that increasing numbers of alumni are becoming serial entrepreneurs, effectively choosing entrepreneurship as a career path like any other. The lines drop in the 1990s and 2000s only because these most recent graduates have not had much time since graduation to start, build and exit from a first firm, let alone to go through the venture formation process a second time.

Figure 21



Social Innovation (non-profits) and Social Entrepreneurs

Some of Stanford's best and brightest engineering and business minds have chosen to found non-profits, creating innovations that do well in addition to doing good. Kiva.org pioneered making it possible for people around the world to loan small amounts to entrepreneurs struggling to found often tiny businesses. Co-founded in 2004 by two Stanford graduates, Jessica Jackley and Matt Flannery, Kiva today raises over \$1 million each week for working people around the world. Embrace (embraceglobal.org), founded by Stanford students in engineering and business and conceived in the d.School's *Design for Extreme Affordability* class, is a venture aimed at reducing infant mortality. The company designed and distributes a low-cost infant warmer that looks a bit like a baby sleeping bag and costs less than 1 percent of the price of a traditional incubator. It will save the lives of premature babies around the world every year. Embrace received the INDEX 2011 People's Choice Award. And in a similar vein, d.light (d.lightdesign.org) designed and sells to poor people around the world a safe, clean, low-cost LED light for use

when electricity is not an option. Its two founders are Stanford MBAs (one also has Stanford undergraduate degrees in computer science and earth systems) who joined with a team of experts in finance and engineering to champion integrity and “quality with extreme affordability.” D.light has received important financing from local and Indian VC firms.

CASE EXAMPLE: ERIC KROCK

Eric Krock has woven together lessons learned in the for-profit and non-profit worlds to become successful in both. As a Stanford student in the early ‘90s he had thought he would make his mark in the for-profit world and then pursue public service, but, as he says, “I realized didn’t want to wait 20 years when there are problems right now.”

After graduating Stanford with a double major in computer science and Asian languages, Krock went to Japan to launch a career with the U.S. software company Interleaf. Returning to the United States, he was a technology evangelist and product manager for Netscape from 1996-2001. While at Netscape he combined what he had learned at his first job about creating educational materials with the technical skills (JavaScript, Dynamic HTML, streaming audio) learned at Netscape to create his first non-profit venture, an educational website StopBadTherapy.com. Founded in 1998, the site provided information in an effort to debunk the controversial form of mental health practice known as memory recovery therapy.¹²

Throughout his career, Krock has continued to meld his insights and skills. Realizing that the easy access to video on demand could make the Internet a great tool for public health education, he created AIDSvideos.org with the goal to prevent new cases of HIV transmission. Krock and Becky Kuhn, M.D., have created 110 original educational videos on HIV/AIDS, some of which have been translated into 13 languages with a combined 3 million views. Experience with low-cost video creation and distribution, search engine optimization (SEO), social media marketing through Twitter and blogs and other skills led to the creation of a "Social Media Marketing Boot Camp" course that he now offers through a Bay Area consultancy called 280 Group.

For-profit and non-profit organizations have different challenges, said Krock. Non-profits aim to maximize change to create a better world but find it harder to attract resources because they are operating in a more resource-constrained environment, without access to venture capital. Thus far Krock’s non-profit ventures have been self-financed, requiring him to focus on inexpensive or free resources.

While for-profits often measure progress through revenue growth or profitability, he said, non-profits traditionally were hesitant to measure their outcomes. Krock disagreed with that approach, and has been relentless in defining measurable outcomes in his non-profit efforts and tracking them. In the case of AIDSvideos.org, the most viewed video *Did I just contract HIV?* has more than 470,000 YouTube views. In the aggregate, the non-profit’s 110 videos have received over 3 million known views, including over 2.4 million on YouTube. The information is valuable because preventing a single new case of HIV in the United States can save over \$600,000 in undiscounted lifetime incremental health care costs if treatment is initiated early, he said.

Bringing a significant product to market, whether in the for-profit world or non-profit world takes time, attention to the right metrics and most of all requires courage, vision and persistence.

¹² http://en.wikipedia.org/wiki/Recovered-memory_therapy

Krock argues there is no perfect path for students interested in both the for-profit and non-profit worlds. “Follow your bliss,” he advises, and hone skills as a critical thinker.

STANFORD CENTERS AND PROGRAMS FOR SOCIAL ENTREPRENEURS

Center for Social Innovation

In the late 1990s business school faculty, the dean’s office, students and alumni recognized an opportunity for the GSB to play a critical role in developing leaders to help solve global social and environmental challenges, creating the Center for Social Innovation. The center provides an executive program for experienced business leaders, sponsors speakers and conferences to bring leading social innovators to campus and sponsors fellowships for students interested in gaining real world experience with social innovation. The school’s Public Management Program, which offers MBA students a specific set of classes to focus on social issues, is part of the center.

Taproot Foundation

Taproot Foundation was founded in 2001 to get business professionals involved in pro bono service. Like another Business School program—Stanford Alumni Consulting Team—Taproot selects nonprofits with a consulting need and assembles teams of consultants with the right experience to assist them. Initially Taproot Foundation focused on marketing, IT and HR services including website development, donor databases and branding. The Foundation has introduced a strategy practice to help nonprofits with key aspects of strategic planning including competitive and financial analysis and metrics.

Haas Center for Public Service

The Haas Center for Public Service is Stanford University's most visible commitment to public and community service. Established in 1985 by then-University President Donald Kennedy, the Haas Center provides ways for Stanford students to connect their academic and service lives. In 1983, Kennedy challenged graduating seniors to dedicate some of their talents to serving society and humanity. As former commissioner of the U.S. Food & Drug Administration, he knew the value of a life in public service. He appointed Catherine Milton as Assistant to the President to evaluate the state of public service at Stanford. Milton found numerous public service efforts by students, but a lack of institutional support and chronic leadership challenges. The Public Service Center was established, renamed the Haas Center for Public Service in 1989.

The Haas Center offers experiential programs for students both within the United States and abroad, service projects, fellowships, voluntary service organizations and coordinates programs with other schools and departments at Stanford.

FUSION

Founded in 1997, Stanford Future Social Innovators Network (FUSION) seeks to educate, inspire, and build a lasting support network for the next generation of leaders hell-bent on tackling the world’s toughest social problems.

Center on Philanthropy and Civil Society

The Stanford Center on Philanthropy and Civil Society (Stanford PACS) develops and shares knowledge to improve philanthropy, strengthen civil society and effect social change. Stanford PACS is a research center that connects students, scholars and practitioners and publishes the journal *Stanford Social Innovation Review* (SSIR) a venue for scholars and practitioners to publish inter-disciplinary and cross sector research and ideas to advance social change. Stanford PACS has relationships with five Schools (Humanities & Sciences, Engineering, Education, Business, and Law) and twenty departments, and leverages the intellectual assets of a diverse, world-class faculty across the University. Its primary participants are Stanford faculty, visiting scholars, postdoctoral scholars, graduate and undergraduate students, and nonprofit and foundation practitioners.

CASE EXAMPLE: MIRIAM RIVERA

Miriam Rivera was not initially drawn to Stanford because of Silicon Valley. Raised in a family of laborers and factory workers, she felt the West offered more opportunities for those who weren't from prestigious and wealthy families that existed in the East. Going to college was her holy grail, and Rivera came to Stanford as part of that quest, eventually earning multiple degrees.

Rivera cofounded a software company, was an early employee and later an executive at Google, and today sits on the Stanford University Board of Trustees. As her career blossomed, her mother's emphasis on philanthropy remained within Rivera. Despite the family's modest means, Rivera's mother made them feel like "we're better off than the next guy so we had to help". Her mother emphasized treating everyone with respect, regardless of social position. She took her mother's focus on others with her when she enrolled in graduate programs at Stanford, sending home \$200 a month of her \$900 monthly earnings.

Today she supports organizations with missions she cares about, giving both time and money to groups that build community and improve educational opportunities. "Education and entrepreneurship transformed the possibilities in my life," Rivera said. She focuses 80 percent of their giving on education-oriented non-profits because they feel this is one of the highest leverage points. If you educate a person, there is so much that comes from it.

She has created the venture capital firm, Ulu Ventures (along with Clint Korver), focusing on IT and companies with Stanford roots. Rivera said that she, like many venture capitalists, often has more experience about financing than the entrepreneurs and so she views the interaction as an obligation to share that knowledge. She says that she works to be a trusted resource where faculty members can send a graduate student for advice on where to turn next.

Rivera earned bachelor's and master's degrees from Stanford before enrolling at Stanford's Graduate School of Business. There she was inspired by Jeff Skoll, a classmate who became the first employee of eBay and later founded the philanthropic Skoll Foundation.. He wrote an article in the school paper bemoaning the fact that so many talented classmates were taking a safe route by going into traditional fields with consulting firms and financial services. Rivera was struck by the idea that if the best and the brightest didn't take any chances, the economy and society would suffer.

Rivera determined that her strongest interest was in using technology to ease the process of acquiring information. As a first-year associate in a consulting firm after earning her JD/MBA, she worked on the InfoSeek IPO, fascinated that the company was creating copies of the entire Internet on its servers and could give answers in seconds.

Together with her husband, she founded On Your Mind Software four years after she earned her JD/MBA degree. The firm struggled financially and at one point she had to let go a close friend she had recruited into the company, but tried to make the process as painless as possible.

A few years later when the same friend, who had by then joined Google, recommended her as an early employee. Google had perhaps 160 employees at that point in 2001 and her prior startup experience and won her the job. Rivera today is a former vice president and deputy general counsel of Google where she led the legal teams for several of the company's operations worldwide. She also served as associate general counsel, managing Google's revenue and commercial partnership practice and as assistant secretary to the board of Google and as a secretary to the board of the Google Foundation, the company's philanthropic arm.

When asked for her advice to future entrepreneurs and Stanford students, Rivera said without hesitation, "Do it—especially women. Do it and early in your career. Younger women should be more risk-taking than they currently are."

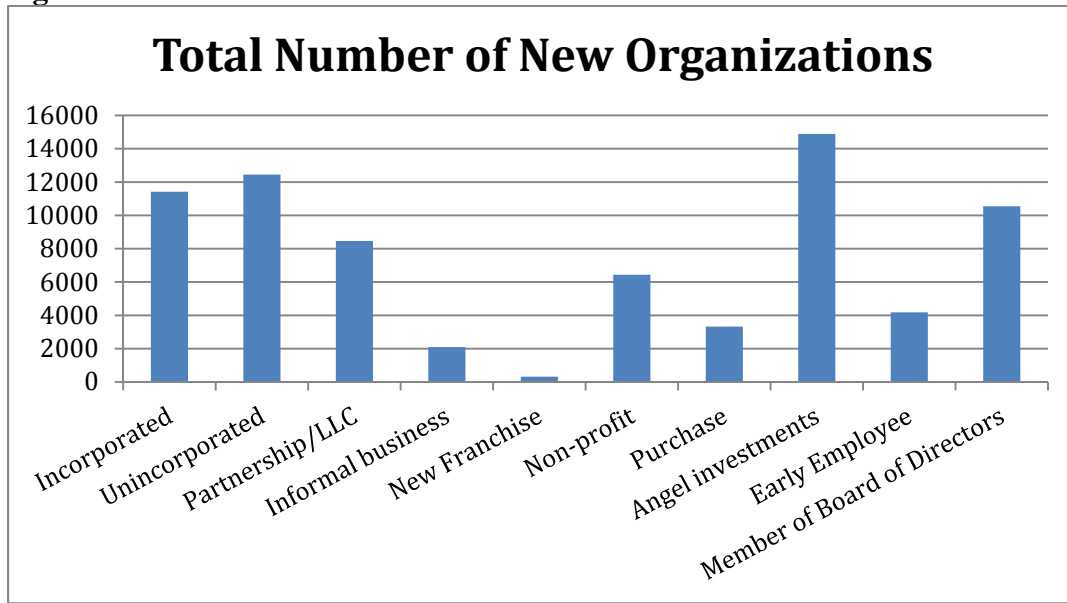
CREATING NON-PROFIT ORGANIZATIONS

Stanford alumni, faculty and staff engage in many different types of innovation, including creating new organizations. In recent years, we've noticed a trend in classes towards increased interest in the creation of non-profit organizations. So we wanted to see if we picked up this trend in the data and how many non-profits Stanford alumni were creating.

In the survey, 2,365 individuals reported having founded at least one non-profit organization in their careers. Similar to the phenomenon of serial entrepreneurship, many of these alumni have created multiple non-profits. Respondents said they had founded 6,432 non-profit organizations. If we extrapolate that up, based on the response rate, Stanford alumni, faculty and staff have created over 30,000 non-profit organizations over the decades. Of course, not all of these survive, but that's quite an impact.

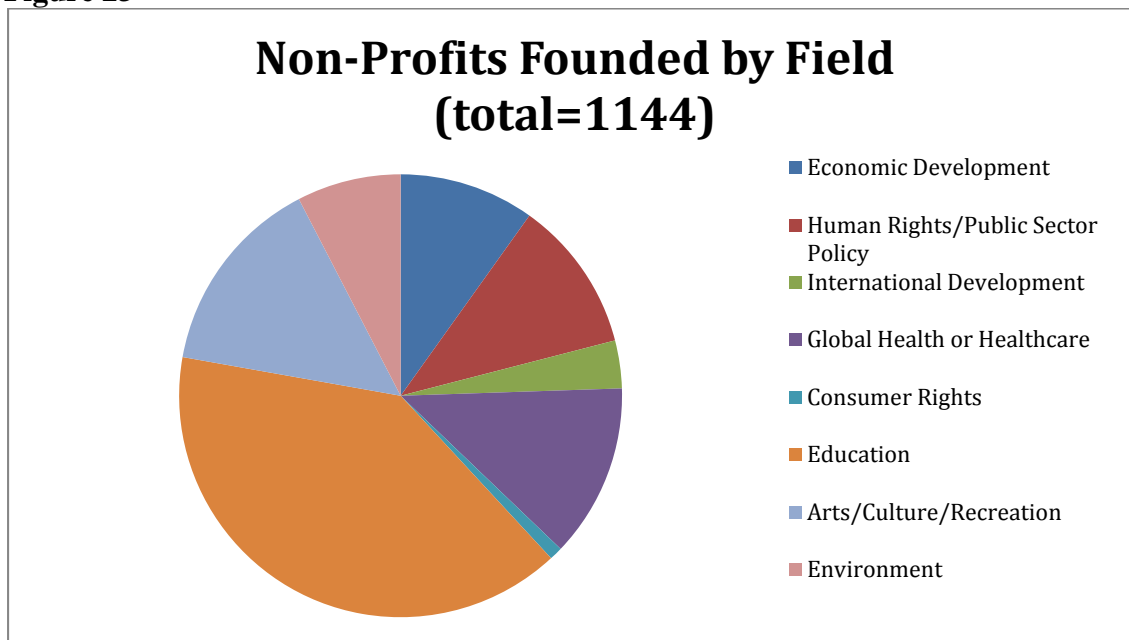
Figure 22 shows the total number of new organizations (including angel investments, early employee positions and board of directors positions) for the respondents.

Figure 22



We also asked what general field the non-profit was operating in. By far the most common type of non-profit created is related to education. The second most frequent response was arts/culture/recreation followed by global health or healthcare. Consumer rights non-profits were the least common.

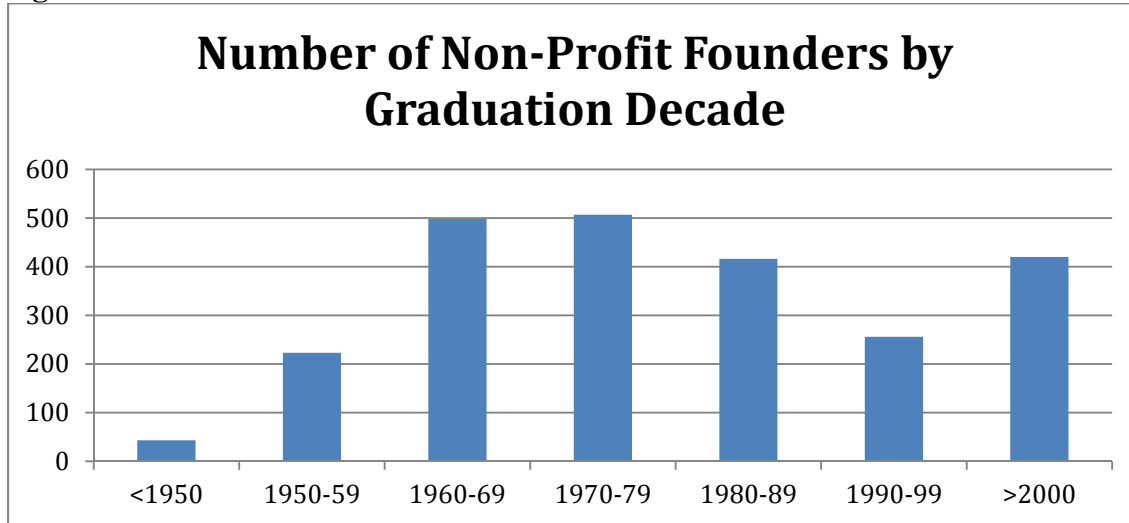
Figure 23



Next, we turn to the graduation year of the non-profit founder. Here we find that the creation of non-profits peaks with graduates from the 1960s and 1970s. We might expect that the downward curve is due to graduates from more recent decades planning to start non-profits later

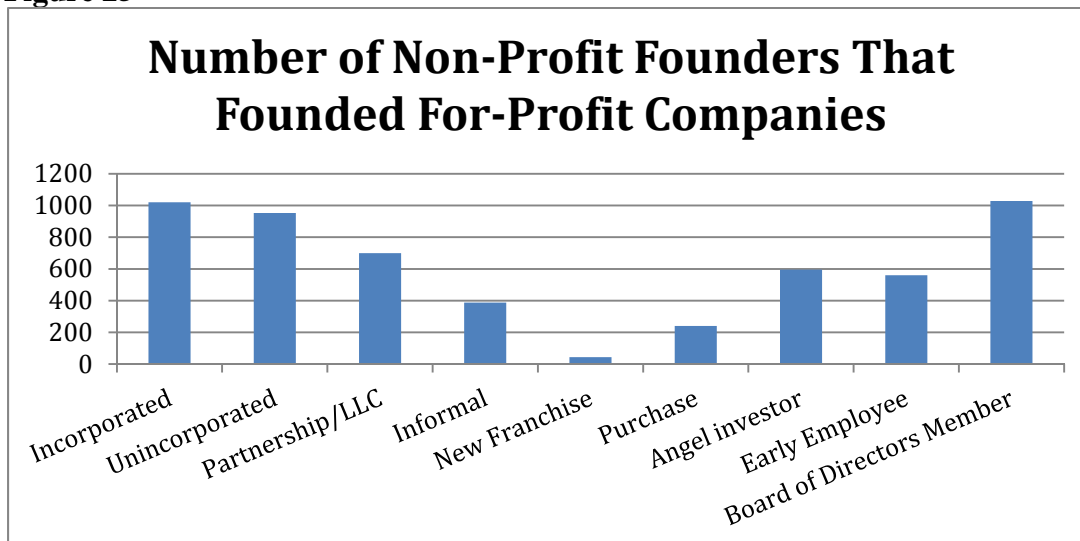
in their careers. Interestingly, confirming the trends noticed in the classroom, we see a big bump upwards in the rate of non-profit creation among students who graduated very recently (in the 2000s). We should also plot these by the year that the non-profit was founded to see if there are similar trends there.

Figure 24



We also studied how many non-profit founders had also started for-profit businesses. In particular, we explored those who had founded an incorporated business or been a board member had also founded a non-profit organization (either before or afterwards).

Figure 25



The final figure shows the proportion of Stanford alumni, faculty and staff who created a for-profit company vs. a non-profit company. While non-profit entrepreneurship has been growing over time, it is still a smaller percentage.

Figure 26

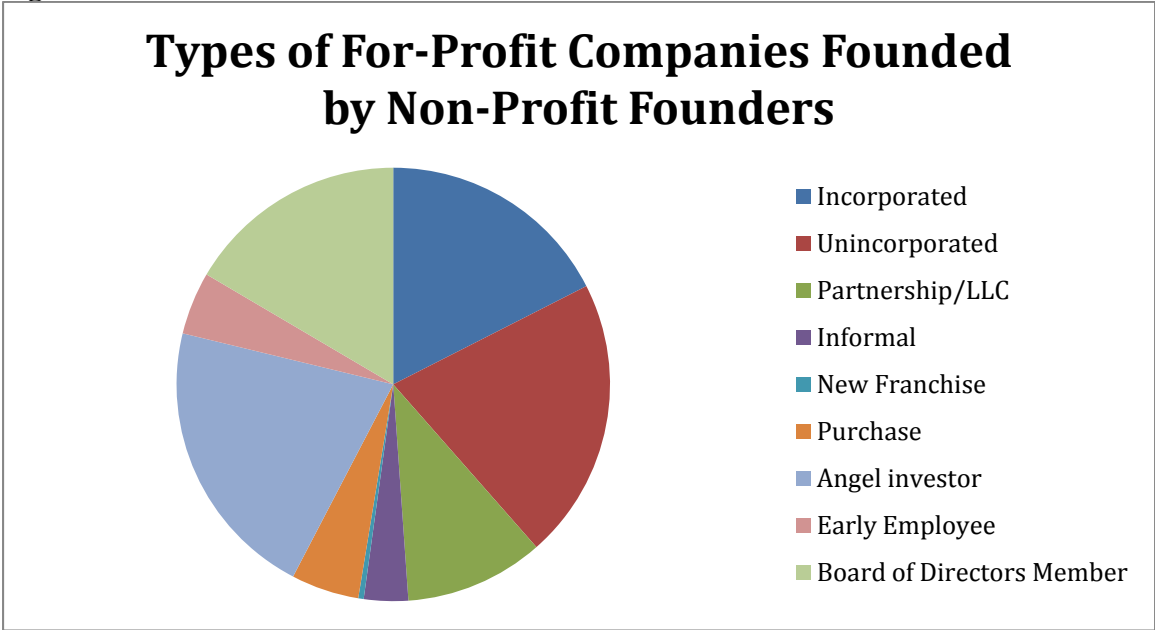


Figure 27

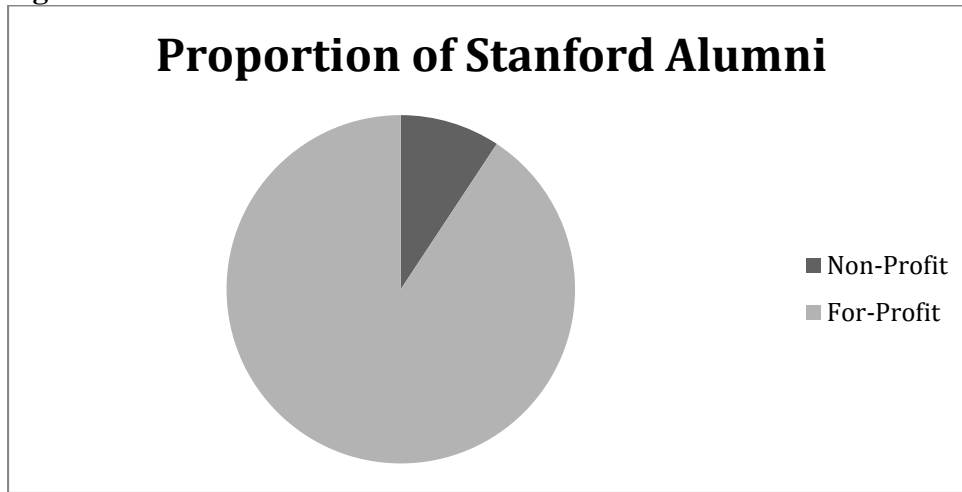


Table 8

	Earth	Edu	Engr	GSB	H&S	JD	Med	<i>Overall</i>
# business founders who also founded non-profits	41	182	426	330	697	139	74	1889
# nonprofits founded by business entrepreneurs	49	256	537	433	988	296	97	2656
# alumni	662	1873	7980	3567	8713	1326	1192	25313
# alumni who founded non-profits	45	220	502	419	829	172	92	2279
# non-profits founded **	54	311	629	572	1217	364	120	3267
Percent of alumni who founded non-profits	6.8%	11.7%	6.3%	11.7%	9.5%	13.0%	7.7%	9.0%

The Lean Startup – Sticking to the Original Vision

Uncertainty is a fact of life for entrepreneurs. New opportunities often arise when there are major technological changes or when entrepreneurs discover new markets or ways to serve new market segments. For large, established companies serving well-known markets often with improved versions of existing products, business planning works well. However, in the case of startups attacking unknown markets with disruptive, sometimes new or not fully proven technologies, a lack of information makes planning difficult if not impossible. Recognizing the high levels of uncertainty and risk inherent in entrepreneurship, many entrepreneurs take advantage of their small size and operate in a more flexible and nimble manner as they explore new opportunities.

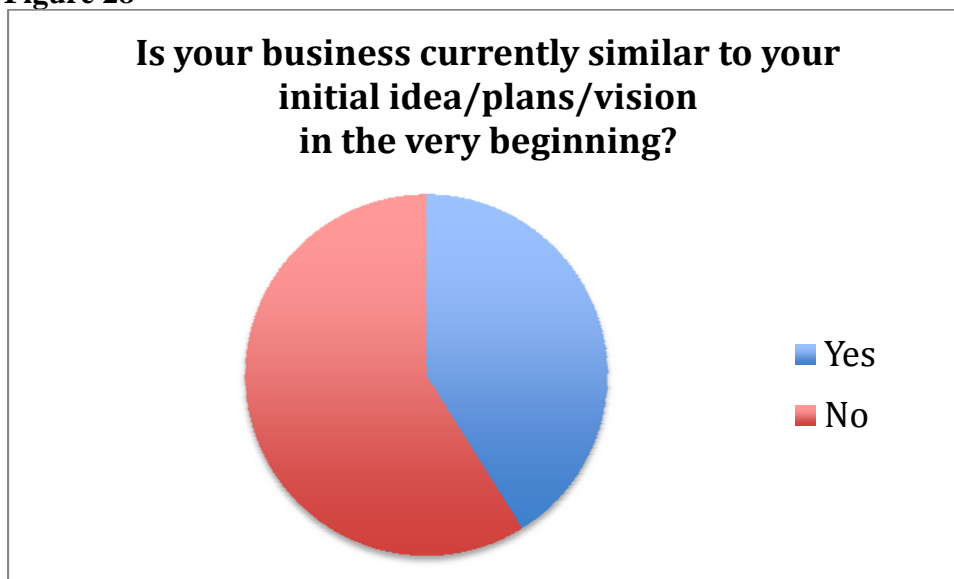
The lean startup process, often known as customer development, has close parallels to the scientific method and with lean manufacturing principles.¹³ Similarly, it is a way to uncover facts about the world and to test hidden assumptions and beliefs held on blind faith. It advises that entrepreneurs think about their entire business model as a set of hypotheses. The task of the entrepreneur is then to identify which hypotheses are the most critical and riskiest to the venture and to design a set of low cost experiments to test each hypothesis in turn.

Through this process, the entrepreneur can be more capital efficient by reducing the biggest sources of risk and determining whether the business model is viable and scalable. Low-cost, early experiments can validate that customers exist and want to buy the product before too much capital is spent on hiring and expanding the business. As entrepreneurs run these early experiments, they often uncover new information about their market or the possibilities in their technology that cause them to “pivot” or shift aspects of their business model. This experimentation, failure and iteration cycle is central to the entrepreneurial process taught at Stanford.

In the survey, we asked questions to verify that entrepreneurs are indeed experimenting, iterating and changing business models. We also wanted to understand what aspects of the business model are most likely to change and whether the entrepreneurs who take this type of more experimental, flexible approach have higher performance in terms of firm growth or survival rates than those who are more inflexible and appear to stick persistently to their initial plans. We found that the majority of entrepreneurs change their business models significantly from their initial vision or idea.

Of the entrepreneurial respondents surveyed, 59 percent said that their business currently is different from their initial vision.

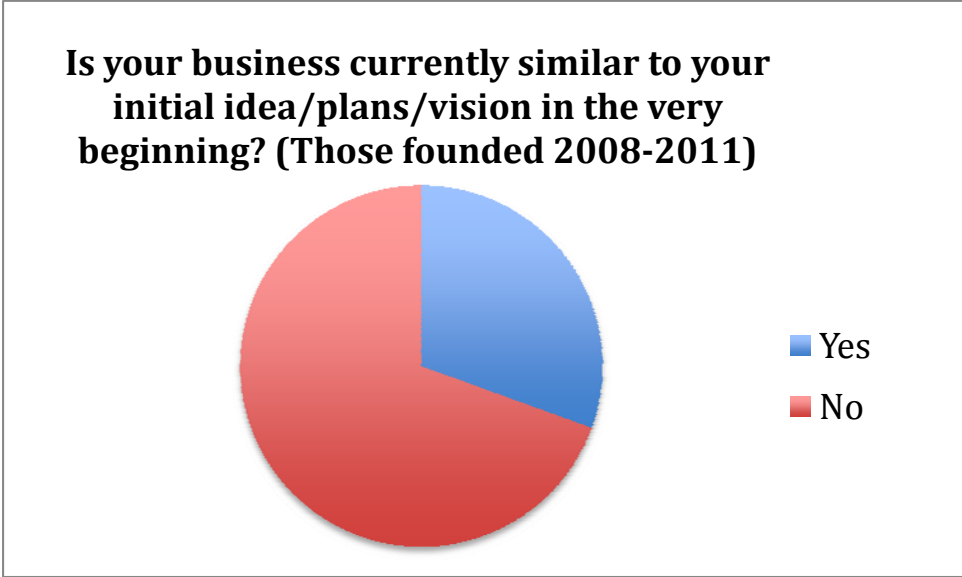
Figure 28



¹³ The Lean Startup movement, developed by Steve Blank, Eric Ries and others has built on the intellectual foundations of the agile software movement and lean manufacturing techniques to crystallize these insights into a process.

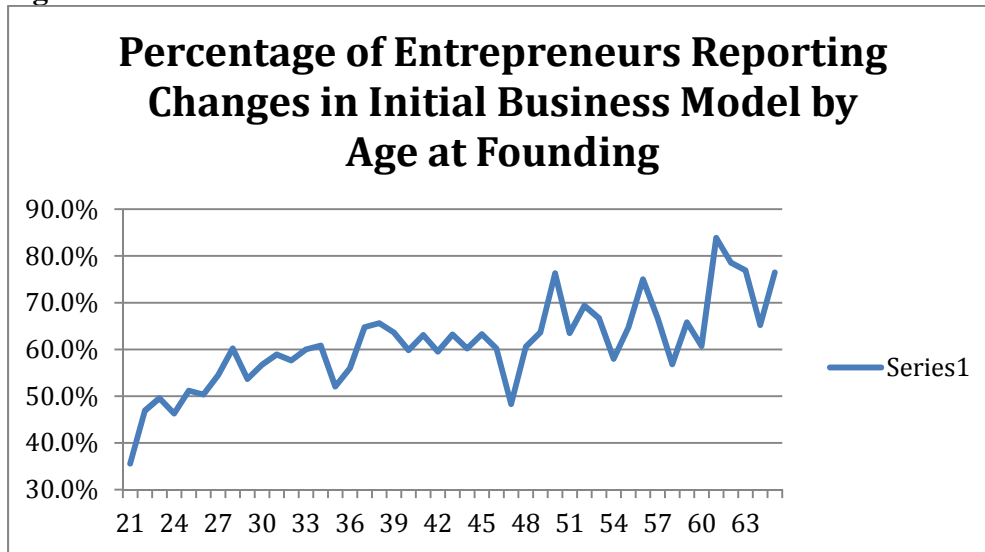
However, this number may be biased downwards as many entrepreneurs who founded their firms decades ago may have had difficulty remembering their first idea for the business. There is a tendency to tell the story of a firm's founding differently in retrospect, relative to the messier process that often occurs along the way. The percentage saying that they changed the business increases to 69 percent when we focus on those who founded companies within the past three years, who are perhaps more likely to be able to recall their initial plans relative to the current business.

Figure 29



Counter to the idea that younger, more inexperienced founders might be more likely to have to pivot their business models, we found that older founders were more likely to change.

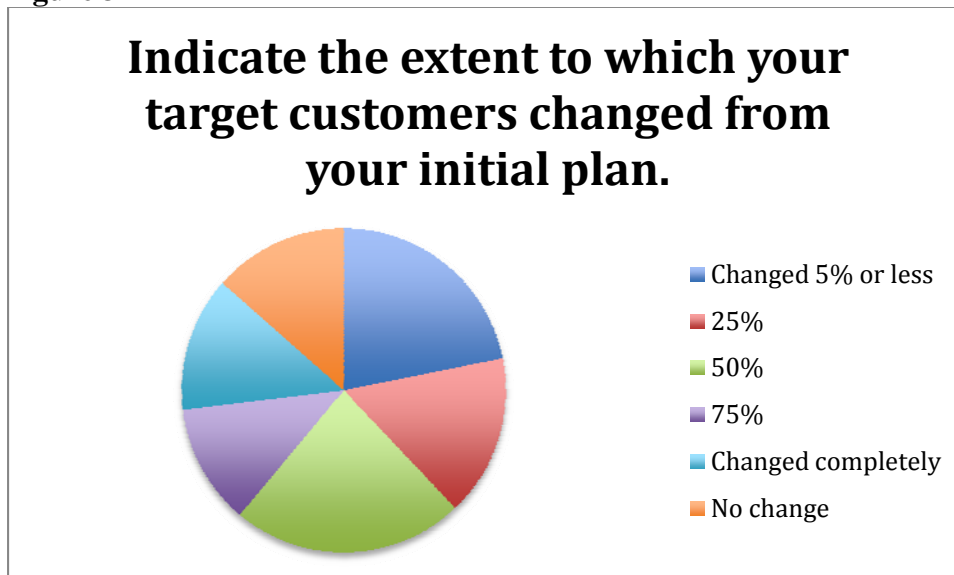
Figure 30



Perhaps these changes are relatively minor refinements and optimization around the edges rather than more significant or fundamental changes. Could it be the case that these changes are confined to a certain area of the business, such as changing the marketing campaign rather than more core areas such as technology, who the customers are and how the business makes money? To do this, we also asked the entrepreneurs to what extent their business model changed within several distinct areas. The results indicate that most entrepreneurs are changing their business models significantly and that these changes are not confined to any single aspect of the business. The data indicate a picture of the early entrepreneurial firm that is often very flexible and nimble.

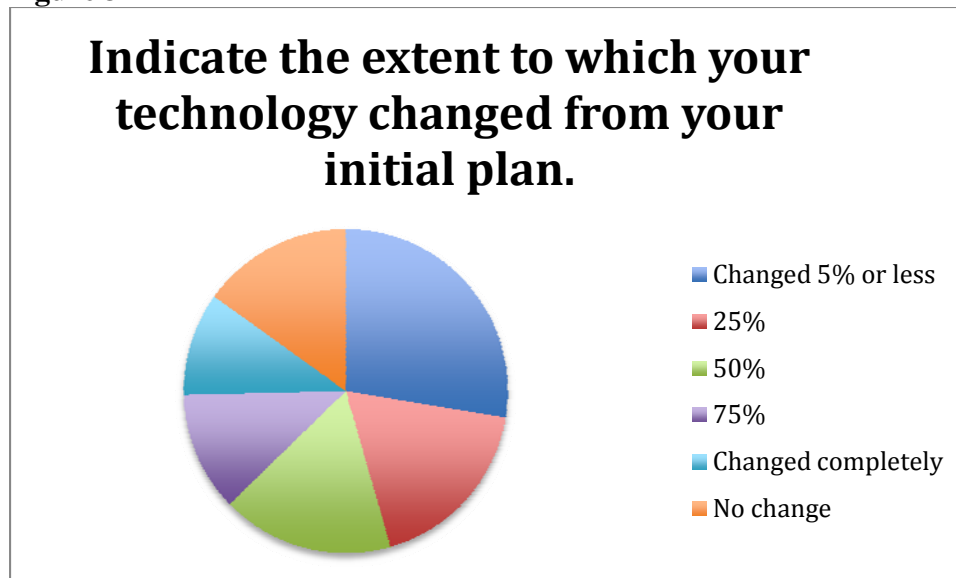
Nearly half, 49 percent, of the entrepreneurs had changed their target customers by what they rated as 50 percent or more. Only 13.5 percent said that there had been no change in their target customers at all and an equal proportion, 13 percent, said that their initial target customers had changed entirely after their early experiments with the business (no overlap at all).

Figure 31



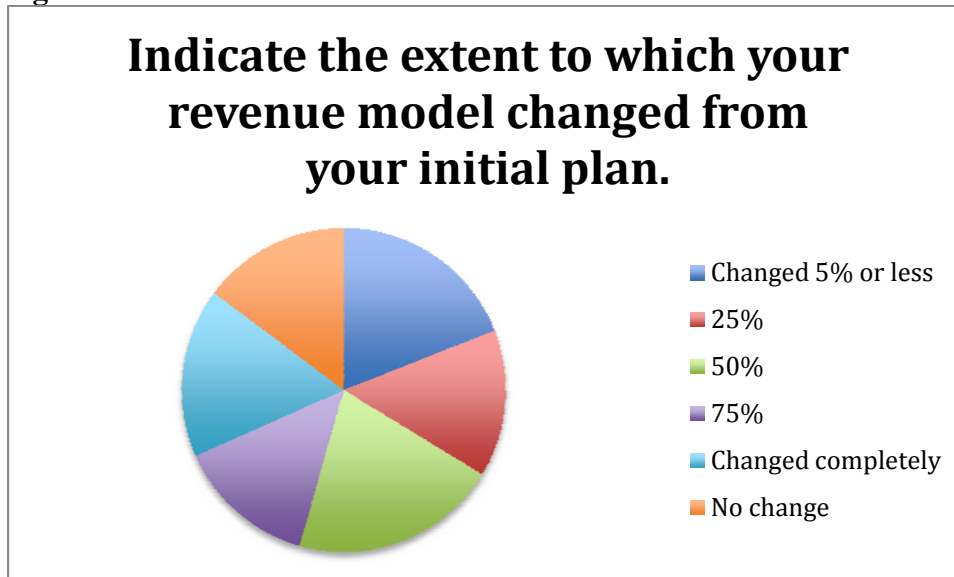
In the next figure, we see that the technological solution being used also frequently changes. Only 43 percent said that the technology had changed by 5 percent or less in their estimation. Forty percent indicated that they technology changed by half or more from their initial plans. Even the technological core of the business appears often to change in response to early experiments and feedback from initial customers.

Figure 32



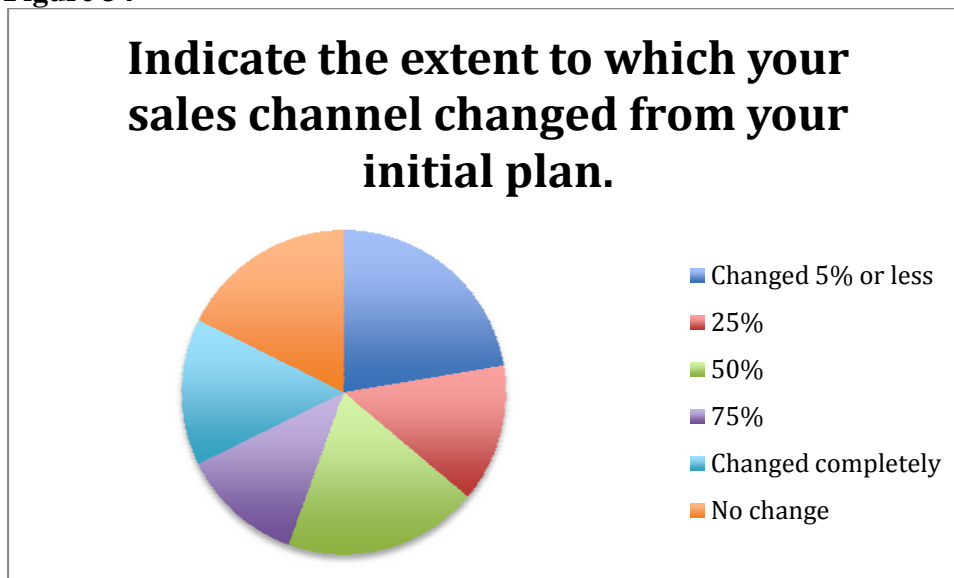
One of the most common changes in the business model is also one of the most central—how the business plans to make money. Fifty two percent of entrepreneurs indicated that their revenue model had changed by half or more from their initial idea. Only 15 percent indicated there had been no change at all in the revenue model.

Figure 33



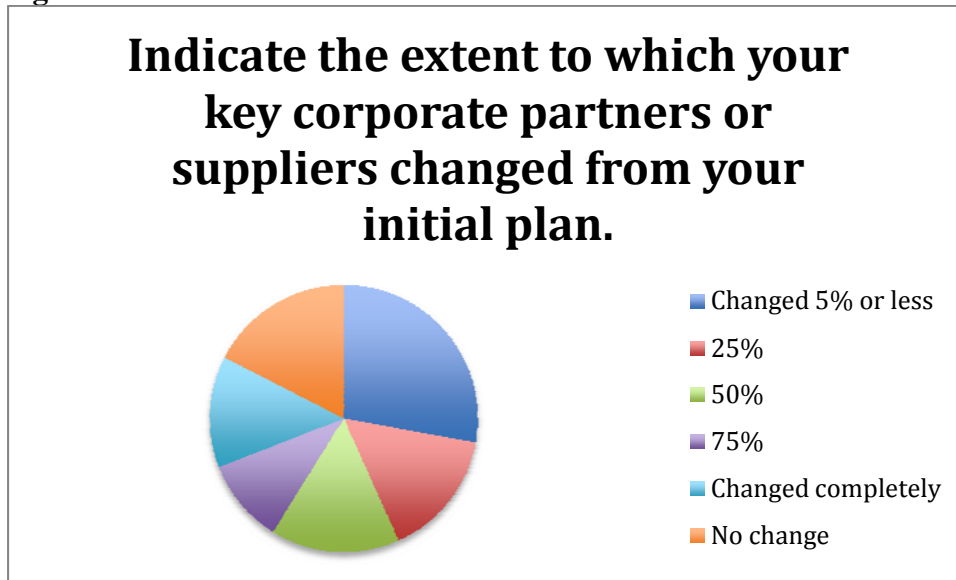
The sales channels through which entrepreneurs plan to reach their customers and sell their products and services also frequently change from the initial plan. A total of 60 percent indicated that the sales channel they had planned at launch shifted by 25 percent or more.

Figure 34



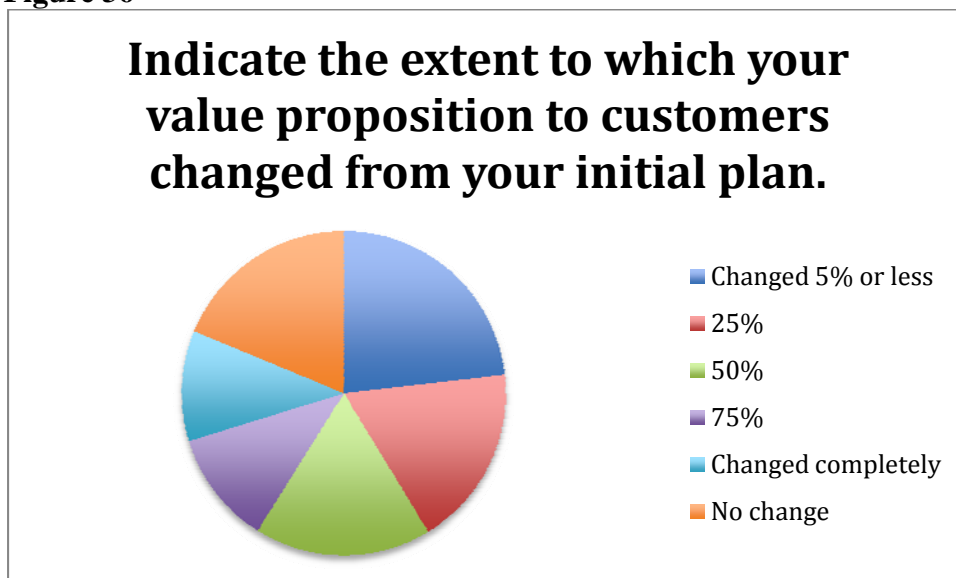
One of the aspects of the business model that changes the least is the plan for key corporate partners or suppliers. But even here, only 45 percent of entrepreneurs indicated a change on the order of 5 percent or less.

Figure 35



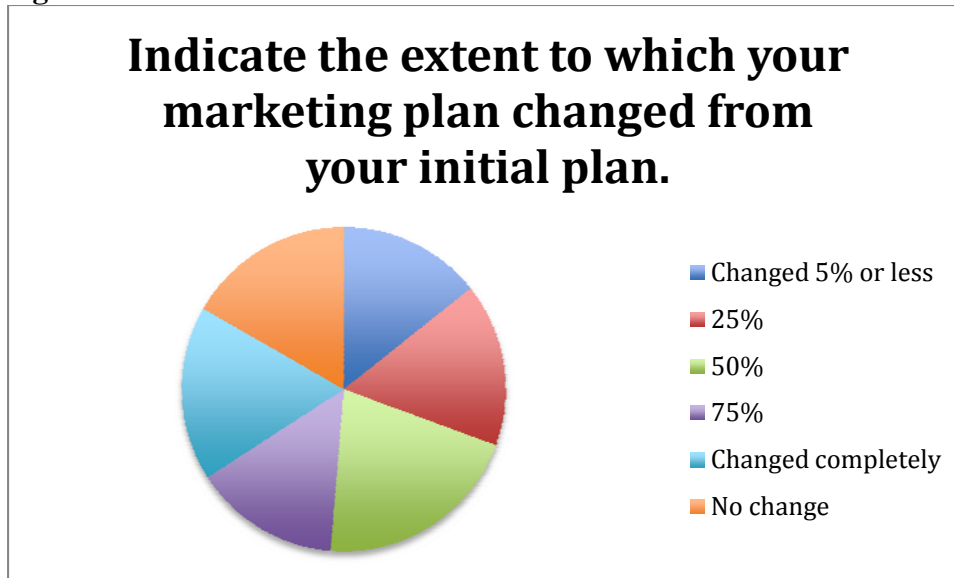
One of the most fundamental aspects of a business is its value proposition, how it creates value for users. Forty percent of the founders said their value proposition had changed in a major way (a 50 percent or greater change). This may be the result of changes in either the target customers or the technological solution being offered. Similarly, a change in the target customer may necessitate a shift in the sales channel as well. Further analysis will explore these possibilities of the most common clusters of changes in the business model.

Figure 36



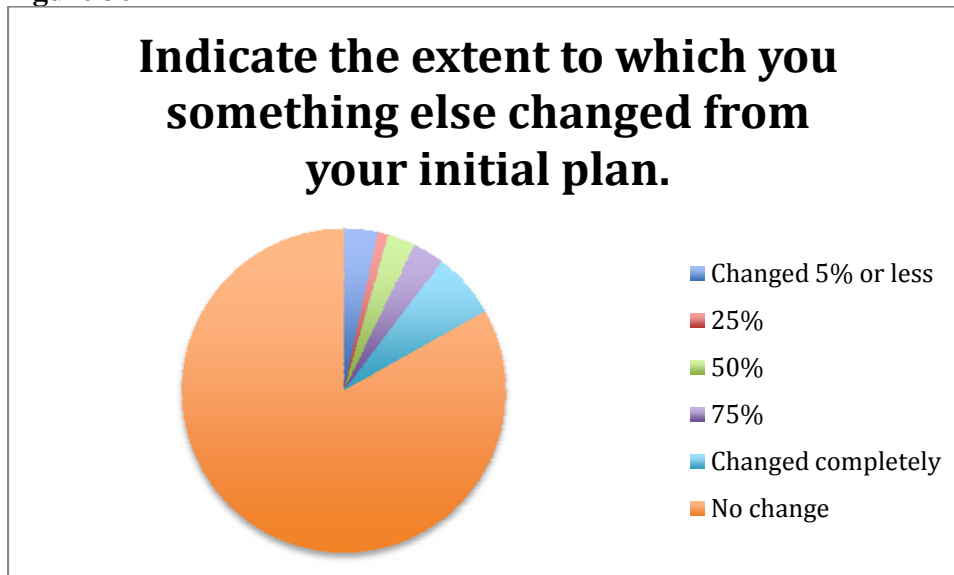
Finally, a majority of entrepreneurs, 53 percent, reported a major change in their initial plans for marketing. Only 17 percent indicated no change from the initial marketing plan.

Figure 37



It appears that these findings covered most of the parts of the business model that changed. We gave entrepreneurs the opportunity to tell us whether there were other components of their business model that changed, and only 17 percent mentioned any other changes.

Figure 38



With so much in flux at the early stages of entrepreneurship, we wondered whether this represented a kind of struggle by firms desperate to try anything. Some might argue that entrepreneurs who know what they are doing and have industry experience should be less likely to be so mercurial. Alternatively, the lean startup model would suggest that the firms that

experimented and changed should be performing at a higher level. We found that the ventures that had changed from their initial plans had significantly lower annual revenues ($p=0.06$). At the mean, this resulted in \$38 million in revenues for firms that changed their initial plans, relative to \$93 million in revenues for those that reported that the business was similar to the initial idea. The outcomes in terms of revenues are highly skewed so at the median, this is a difference of \$150,000 vs. \$200,000 in revenues and at the 75th percentile the numbers are \$1.2M vs. \$2M for the firms that were more similar.

These results correspond well with earlier evidence from the Startup Genome Report (<https://www.startupcompass.co/>) which showed that entrepreneurial ventures with too many pivots and that scale up prematurely had significantly lower performance as measured by inflation-adjusted revenues. These results also point out that it's not change in and of itself that helps startup performance, but more likely it's responsiveness to feedback from customers and partners that matters.

Finally, we tested whether certain industries might benefit from a more flexible process of iterating on the business model. We separated out software and Internet firms and examined their performance according to whether the founders said their business model had changed from their initial vision and plans. Here we found that those Internet and software firms where the business plan was similar to the original one had significantly lower performance. Startups that had changed had mean revenues of \$56 million (median= \$500,000) and startups that had not changed had mean revenues of just under \$9 million (median= \$200,000). These differences are statistically significant at the 5 percent level.

At this point we cannot determine why these industry differences appear, so we leave this to future research. However, we can speculate that perhaps in software firms, solving deep technical problems is less of an issue and the industry moves at a high enough velocity that sorting out the right business model, including target customers, the problem to solve and how to structure the business become the greater challenges. In this type of industry, persistently sticking to an initial idea may do more harm than good.

A total of 4,294 respondents described the one or two concrete things that they wish they had known when they first had the idea for the startup. We are analyzing this data to inform what we should emphasize more in our classes on entrepreneurship. Few of the entrepreneurs mentioned technical knowledge. Most mentioned things like legal issues, accounting, marketing, sales, management, the slow pace of the process, the difficulty of raising funds or wished desire to have known their cofounders better.

How Stanford Supports Entrepreneurship – Programs, Centers, Projects, etc.

Understanding how to structure a company so a product can be taken to market is not intuitive. Even when taught in engineering and business curricula, it is best learned through experience. Entrepreneurs thrive when they have places to share ideas and find the creative stimulation essential to generating the next new thing. Stanford's approach is to encourage proximity and the back-and-forth exchange that occurs between the campus community and fledgling and established businesses. The university understands it is vital to provide an environment that shows young entrepreneurs how it can be done, how the transfer of technology can take place, how an idea can become a product. This approach has proven successful across

many startups and industry sectors, including information technology, biotechnology and service industries (including legal and venture capital firms).

The recent institutional broadening of support can be classified into faculty-led including centers, projects and programs, formal academic classes, and conferences and workshops, student-led including initiatives, and alumni-led initiatives.

STANFORD TECHNOLOGY VENTURES PROGRAM

The Stanford Technology Ventures Program (STVP) is an entrepreneurship center located within Stanford's School of Engineering. Its faculty and PhD students make up one of the leading entrepreneurship research programs in the world. Created in 1996 by Professor Tom Byers and colleagues, the Department of Management Science and Engineering hosts the center, which is dedicated to accelerating high-technology entrepreneurship research and education for engineers and scientists worldwide. STVP supports academic research on high-technology entrepreneurship, and its faculty teach a wide range of courses to Stanford science and engineering students. The outreach efforts include annual conferences, campus-wide collaboration, and dissemination of teaching content through the ECorner website. These research initiatives include the West Coast Research Symposium on technology entrepreneurship.

The Spirit of Entrepreneurship course offered through the STVP helps students develop a portfolio of skills that prepare them to add value to established companies, government agencies and nonprofit organizations. The center offered 31 courses and served 2,350 graduate and undergraduate students at Stanford in 2011. Many industry leaders, venture capitalists and entrepreneurs—including John Doerr, Steve Jurvetson, Peter Thiel, Don Valentine, Craig Barrett, Jerry Yang, David Filo, JB Straubel, Jen-Hsun Huang and Lorry Lokey—also give guest lectures and lead symposia on technical and business topics.

MAYFIELD FELLOWS PROGRAM

The Mayfield Fellows Program is an intensive, nine-month work/ study program designed to develop a theoretical and practical understanding of the techniques for developing emerging technology companies. Coursework is combined with summer internships at startups and mentoring and networking activities. Since 1996, nearly 200 students have gone through the Program.



Mayfield Fellows celebrated the culmination of the nine-month program with Tina Seelig, executive director, STVP

This program provides an in-depth, 9-month work/study experience for 12-15 top science and engineering students each year. Approximately 25 percent of Mayfield Fellows alumni have been on the founding team of a company.

Here is a snapshot of MFP startups.

As of December 2011:

184 Alumni / 46 Founders / 52 Startups / 4 Founding Teams / 10 Acquisitions

Alex Gurevich (2005) - **sayheyhey, ooma, DFJ aurora**
 Armen Berjiky (2001) - **Experience Project**
 Avid Larizadeh (2000) - **Boticca.com**
 Ben Jun (1996) **Cryptography** - acquired by Rambus
 Ben Olding (1999) - **Jana**
 Brian Biggott (2004) - **Transom Capital Group**
 Camille Hearst (2004)- **Channel Entertainment Services**
 Chris Gory (1996) **Cryptography** - acquired by Rambus
 Clara Shih (2004) - **Hearsay Social**
 Dave Merrill (2001) - **Sifteo**
 Eileen Long (1998) - **FairSoftware**
 Elizabeth Weil (2003) **Paperwheel Press**
 Evan Tana (2005) - **Loopt, shopkick**
 Guha Jayachandran (2003) - **Cruxlux** - acquired by Kosmix
 Ian Lee (2010) **Loki Studios** in 2010
 Jeff Seibert (2007) - **Increo** acquired by Box.net, **Crashlytics**
 Jonah Greenberger (2008) - **Project Ballast**
 Jonathan Berger (2004) - **Maroon Labs**
 Josh McFarland (1999) - **MyTwoFrontTeeth**
 Josh Reeves (2005) – **Switchboard Labs; unwrap, inc.**

acquired by Context Optional; **TECC**
 Josh Schwartzapel (2007) - **Cooliris, Limelight Labs**
 Justin Fishner-Wolfson (2003) **137 ventures**
 Justin Rosenstein (2003) - **Asana**
 Justin Smith (2003) - **Inside Network**
 acquired by WebMediaBrands
 Kelly Bayer Rosmarin (1998) – **CustomInsight**
 Kevin Systrom (2005) - **Instagram**
 Kim Chen (2002) **Tjoos.com** acquired by Internet Brands
 Kit Rogers (1996) - **Cryptography** acquired by Rambus
 Mark Shaw (1997) - **Guidewire Software, Strava**
 Mike Krieger (2007) **Instagram**
 Mauria Finley (1996) **Citrus Lane**
 Melissa Miao (2001) - **CMP Healthcare**
 Mitali Dave (1997) - **Issueback**
 Nathan Eagle (1999) - **Jana**
 Nolan Glantz (1996) - **Cithaeron Partners/The Cantor Exchange**
 Ping Wang (2001) **VAE Corporation**
 Rajit Marwah (2002) - **Plate**
 Russ Heddleson (2006) **Pursuit.com** acquired by Facebook
 Scott Bowie (1998) - **Zao Technology Innovators**

Scott Kleper (1999) - **Context Optional** acquired by Adobe
Steve Garrity (2004) **Hearsay Social**
Sunaina Sinha (2002) **Cebile Capital, Mantra London, Sekai Guide**

Tristan Harris (2006) - **Apture**, acquired by Google
Vivek Agrawa (2006) **NoiseToys**
Vivian Chiang (1998) - **Orbit Baby** acquired by ERGObaby
Yael Pasternak (1998) - **MayasMom, Kiwi Crate**

The following are quotes from a few alumni of the Mayfield Fellows Program.

MFP has shown me a real path to changing the world through technology entrepreneurship, and left me feeling that – when and if the time comes – I really could start and lead my own company.

The Mayfield Program has strengthened my resolve and fueled my confidence. I feel ready to change the world!

The DFJ Entrepreneurial Thought Leaders Seminar is a weekly speaker series that brings innovation leaders from business, finance, technology, education, and philanthropy, to share their insights with aspiring entrepreneurs from all over the world.

ENTREPRENEURSHIP CORNER

The Stanford Technology Ventures Program (STVP) Entrepreneurship Corner <http://ecorner.stanford.edu> is a free online archive of entrepreneurship resources for teaching and learning created to support and encourage faculty around the world who teach entrepreneurship and related topics.

The Entrepreneurship Corner (ECorner) website, launched in 2001, features a growing collection of over 2,000 videos and podcasts. Roughly 40 percent of visitors are from outside the United States and videos are translated into a half-dozen languages by volunteers. The ECorner podcasts are downloaded over 10,000 times per day, and they are consistently ranked as the most-popular podcast in the Higher Education category on iTunes.

CONFERENCES AND WORKSHOPS

Created in 2007, Entrepreneurship Week, organized by the Stanford Entrepreneurship Network (SEN), brings together the campus community, local business leaders, community leaders and alumni. There are talks, focus groups and competitions, as well as ample opportunity for socializing and brainstorming.

Accel REE Conferences

The Accel Roundtable on Entrepreneurship Education Conferences bring together business, engineering, science and design faculty from around the world, interested in building leading-edge entrepreneurship programs. They provide an opportunity to learn best practices for developing entrepreneurship programs and to discover the latest strategies in experiential entrepreneurship learning.

International Partnerships

Stanford Technology Ventures Program has formed three strategic international partnerships, built to push the limits as change-makers in entrepreneurship education around the world. Two university partners, *Pontificia Universidad Católica* and the *Universidad Del Desarrollo*, are located in Santiago, Chile, and the third partner, *Aalto University*, is in Helsinki, Finland. Stanford professors have visited both Chile and Finland, and three groups of ten faculty from each university have spent one week visiting Stanford University with STVP as a host. During their stay, they had the opportunity to meet with Stanford staff and faculty, observe STVP and d.school classes, participate in workshops, meet with Mayfield Fellows and PhD students, and develop a common team project or objective to take home with them.

Stanford Entrepreneurship Network (<http://sen.stanford.edu>)

The primary purpose of SEN is to bring Stanford's various entrepreneurship programs together under one umbrella. Directed by STVP, the Entrepreneurship Network benefits students, faculty, staff, alumni and all members of the entrepreneurship community by:

- Serving as a single point of contact for all things entrepreneurship at Stanford
- Helping students and others to find and access-appropriate entrepreneurship resources at Stanford
- Advancing a multi-disciplinary approach to entrepreneurship teaching, research and outreach both within and outside of Stanford

SEN benefits member organizations, and thus their constituents, by:

- Making them aware of other entrepreneurship activities on campus
- Helping them communicate with each other about their programs
- Enable colleagues to meet, share resources, and gain synergies across campus
- Facilitating collaboration on specific projects
- Encouraging referrals between all members of SEN

Each year SEN hosts Entrepreneurship Week to showcase the range of entrepreneurship-related programs on campus.

Member organizations:

Graduate School of Business (GSB)
Center for Entrepreneurial Studies
Center for Social Innovation
Graduate School of Business (GSB)
Entrepreneur Club
GSB Energy Club
School of Engineering (SoE)
Asia Technology Initiative
Product Realization Network
Stanford Institute for Electrical and
Electronics Engineers

Stanford Technology Ventures Program
US-Asia Technology Management Center
Multidisciplinary
Association of Industry-Minded Stanford
Professionals
Cross-disciplinary Healthcare Innovation
Partnership
European Entrepreneurship & Innovation
Stanford IP Innovation Society
Stanford Media X
Woods Institute for the Environment

Graduate Program in Journalism: Digital
Media at Stanford
Office of Technology Licensing
School of Medicine

School of Medicine Career Center
Freeman Spogli Institute for International
Studies
Stanford Program on Regions of Innovation
and Entrepreneurship
Student Groups
Asia-Pacific Student Entrepreneurship

Society
Business Association of Stanford
Entrepreneurial Students
Society for Entrepreneurship in Latin
America
Stanford Energy Club
Stanford Law & Technology Association
Stanford Venture Capital Club
Stanford Women in Business
Spark
School of Medicine Career Center

EPICENTER - NATIONAL CENTER FOR ENGINEERING PATHWAYS TO INNOVATION

In July 2011 the National Science Foundation awarded a five-year, \$10 million grant to The Stanford Technology Ventures Program to launch a national center of innovation and entrepreneurship in engineering. STVP is partnering with the National Collegiate Inventors and Innovators Alliance on the center, which will be located at Stanford and involve faculty across the United States. The National Center for Engineering Pathways to Innovation, called EPI.Center, launched September 14, 2011 with the mission to create bold innovators with the knowledge, skills and attitudes to contribute to the prosperity of the U.S. economy and society at large.

The EPI.Center intends to catalyze a wave of change in undergraduate engineering education in the U.S. through initiatives that inspire students to envision possibilities and create viable, innovative products, services, and processes for lasting economic and societal contributions.

I-Corps

The NSF Innovation Corps (I-Corps) guides promising research with commercial potential out of university laboratories. Based on STVP's *Lean Launchpad* course taught by Steve Blank, Jon Feiber, and Ann Miura-Ko, the I-Corps program is designed to assess the readiness of emerging technology concepts for transitioning into valuable new products through a public-private partnership.

The NSF Innovation Corps program brings together technological, entrepreneurial and business know-how to bring discoveries ripe for innovation out of the university lab. While the knowledge gained from NSF-supported basic research frequently advances a particular field of science or engineering, some results also show immediate potential for broader applicability and impact in the business world. These results may be translated into technologies with near-term benefits for the economy and society.

OTHER STANFORD PROGRAMS SUPPORTING ENTREPRENEURSHIP

Center for Entrepreneurial Studies

The Graduate School of Business's Center for Entrepreneurial Studies (CES) has explored issues faced by entrepreneurial companies and individuals for 15 years. The center provides personalized counseling, introductions between fledgling entrepreneurs and the venture capital community, liaison between experienced and new entrepreneurs for mentorship purposes and supplementary funding to first-year MBA students who find summer employment with an entrepreneurial company that cannot pay competitive wages. It also collaborates with faculty, students, alumni and the broader Silicon Valley community to create events which support entrepreneurial activities such as the annual Conference on Entrepreneurship, featuring prominent entrepreneurs and investors in a series of interactive panels and talks.

In addition, the Stanford Graduate School of Business (GSB) supports entrepreneurship and the development of commercial ventures with classes such as *Creating a Startup*, and by providing opportunities for students to engage directly with Silicon Valley leaders. Students are given opportunities to pitch their business plans to area business leaders who provide feedback.

Stanford Program on Regions of Innovation and Entrepreneurship (SPRIE)

The Stanford Program on Regions of Innovation and Entrepreneurship (SPRIE) is focused on Silicon Valley and high technology regions across Asia, including in China, India, Japan, Korea, Singapore and Taiwan. SPRIE supports and encourages interdisciplinary and international collaborative research, publications and briefings for industry and government leaders, and workshops, and conferences in the United States and Asia for scholars as well as leaders in government and business.

SPRIE research focuses on the nexus of innovation and entrepreneurship in high technology clusters, through questions such as:

- What factors enable innovative and entrepreneurial regions to advance and be sustained?
- What divergent models and strategies are evident in emerging regions?
- Why have some regions lagged, despite strong assets such as skilled workers or capital investments? What obstacles hinder a region's development?
- How can the performance of high-technology regions be analyzed and evaluated?

As new firms and technological advances are expanding in regions across Asia, SPRIE brings together a team of distinguished faculty, researchers, visiting scholars, and students from business, political science, economics, and technology. SPRIE also conducts research through international, interdisciplinary collaboration with scholars at other eminent research institutes and universities, and partnerships with leading international/high-technology firms.

Examples of Projects within SPRIE include:

- *Stanford Project on Japanese Entrepreneurship (STAJE)*
- *China 2.0 Program*
- *Smart Green Cities*
- *Silicon Valley Project*

Stanford Institute for Innovation in Developing Economies (SEED)

Created in 2012 in the Graduate School of Business, the mission of the Stanford Institute for Innovation in Developing Economies (known as SEED) is to enable entrepreneurs, managers, and leaders to alleviate poverty in developing economies by stimulating, developing and

disseminate research and innovations. The Institute's work is based on the belief that a critical route for economic growth is through the creation of new entrepreneurial ventures and by scaling existing enterprises.

It has a three-pronged approach: to conduct multidisciplinary research with in-the-field managers; to educate Stanford students from around the world as well as entrepreneurs, social entrepreneurs, managers, and leaders in developing economies to enable them to relieve poverty through effective leadership and problem-solving, and to build capacity on the ground to support action by entrepreneurs, managers and leaders to scale their organizations and spur innovation.

Hasso Plattner Institute of Design (d.school)

The d.School, founded in 2005, is a non-degree program that teaches students across the university to use design methodology to tackle problems in their own fields. The school works with about 350 students from law, business, education, medicine and engineering.

Formally known as the Hasso Plattner Institute of Design at Stanford, the program was founded in the School of Engineering to prepare a generation of innovators to tackle these complex challenges. The institute brings students and faculty from radically different backgrounds together to develop innovative, human-centered solutions to real-world challenges.

d.School courses and curriculum are based on the design thinking process. It draws on methods from engineering and design, and combines them with ideas from the arts, tools from the social sciences, and insights from the business world. The process brings teammates together around a common goal: make the lives of the people they're designing for better.

Every class at the d.school is taught by a team drawn from more than 70 faculty members from across the Stanford campus and industry. For example, recently, Stanford political scientist Joshua Cohen and Computer Science pioneer Terry Winograd taught Designing Liberation Technology, exploring how cutting-edge technology can be used to spread development and democracy in Africa.

Classes require real-world projects and recent partners include: Facebook, Procter & Gamble, SFMOMA, International Development Enterprises, Kaiser Permanente, Google, Henry Ford Learning Institute, Timbuk2, WalMart, JetBlue Airlines, Mozilla Foundation, and Electronic Arts.

Highlights

- The Entrepreneurial Design for Extreme Affordability class has developed a global reputation for producing innovative solutions to problems facing people in the developing world. Five companies have been created out of student class projects including non-profit Embrace Global, which makes an infant warming device that costs less than 1 percent of a traditional incubator. This device is positioned to save the lives of 100,000 premature babies in the next three years. The d.school's K-12 Lab develops curriculum, offers regular teacher workshops, and helps schools as far away as India to create design challenges around the world.
- John Keefe, the Executive Director of New York public radio station WNYC, partnered with the Media+Design class to come up with new ideas for a recently launched morning radio show. He now uses design thinking to help transform his organization:

Bio-X and BioDesign

In May of 1998 a group of Stanford faculty, led by James Spudich, organized a grass roots effort to initiate a bold enterprise known informally as Bio-X to facilitate interdisciplinary research and teaching in the areas of bioengineering, biomedicine and biosciences. The program operates across the Schools of Humanities and Sciences, Engineering, Medicine, Earth Sciences and the School of Law.

The BioDesign program—started in 2000 with a course and fellowship within Bio-X—is a Stanford University initiative encouraging multidisciplinary approaches to biology and medicine. The program is focused on the invention and implementation of new health technologies through interdisciplinary research and education at the emerging frontiers of engineering and the biomedical sciences.

Three key features are at the heart of the program:

- (1) It focuses on the invention and early testing of technologies that are directly targeted at clinical and healthcare needs.
- (2) It is explicitly interdisciplinary, with faculty and students from multiple departments in the schools of engineering, business, humanities & sciences and medicine.
- (3) It has as a main educational goal to look for translational opportunities in areas that are considered basic science domains—for example, nanotechnology and cellular and molecular biology.

SPARK

Established in 2006, SPARK was created to capitalize on Stanford's unique resources by removing some of the obstacles inherent in improving research. Obstacles can range from increased competition for federal support for basic research to the need for unique and costly specialized facilities and services. It provides the infrastructure to bring investigators involved in translational research together to generate new drugs and treatments. It provides a structured focus for these activities, accelerating the testing of potential benefits derived from scientific discovery. It helps streamline communication between academia and industry, clarifying the language and assumptions of these disparate groups.

The program promotes new ways of thinking about how research can be applied to workable solutions. Its broad base of participants allows new and unique perspectives on projects that may have lost momentum on their original premise. SPARK can help identify failures that may show potential in seemingly unrelated applications, allowing other participants to pick up the pieces of another project.

- Case Report Forms
- Coordinating with other departments and specialties
- Confidentiality
- Protocol development and deviations
- Preparing adverse event documentation
- Data Safety Monitoring Boards

Applicants submit a letter of intent to the SPARK committee, which reviews the proposal and makes funding recommendations on a quarterly basis. Funding may be awarded for activities that will advance the project toward the clinical stage, such as preclinical studies to identify

compound toxicity or high throughput screening to identify potential therapeutic compounds. SPARK fills the void between laboratory work and the delivery of products, increasing the value and readiness of commercial interventions. Very little funding is available from the NIH, foundations or private enterprise for this transition.

SPARK supports faculty and fellows in the process of discovering, refining and testing potential new therapies, products and tools. SPARK is designed to identify partnerships between academia and enterprise to allow these discoveries to move from Stanford's laboratories to pragmatic applications for human health.

Classes in Entrepreneurship Taught through STVP and the GSB

Sample STVP Courses

ENGR 140 A,B,C [undergrad]

Leadership of Technology Ventures

ENGR 145 [undergrad]

Technology Entrepreneurship

MS&E 140 [undergrad]

Accounting for Managers and Entrepreneurs

MS&E 175 [undergrad]

Innovation, Creativity, and Change

MS&E 178 [undergrad/grad]

The Spirit of Entrepreneurship

MS&E 180 [undergrad]

Organizations: Theory and Management

ME 208 [grad]

Patent Law and Strategy for Entrepreneurs

MS&E 408 [undergrad]

Leading Durable Organizations

MS&E 101 [grad]

The Boardroom

ENGR 245 [grad]

Technology Entrepreneurship & Lean Startups

MS&E 270 [grad]

Strategy in Technology-based Companies

MS&E 271 [grad]

Global Entrepreneurial Marketing

MS&E 273 [grad]

Technology Venture Formation

MS&E 276 [grad]

Entrepreneurial Management and Finance

MS&E 277 [undergrad/grad]

Creativity and Innovation

MS&E 280 [grad]

Organizational Behavior and Management

MS&E 371 & 376 [grad]

Doctoral Research Seminars

MS&E 472 [undergrad/grad + open to public]

Entrepreneurial Thought Leaders Seminar

Sample GSB Courses

FINANCE 319	Private Equity Investing Seminar	POLECON 347	Intellectual Property & Its Effect on Business
FINANCE 321	Investment Management and Entrepreneurial Finance	STRAMGT 351	Building and Managing Professional Sales Organization
FINANCE 329	Investment Seminar	STRAMGT 353	Entrepreneurship: Formation of New Ventures
GSBGEN 306	Real Estate Investment	STRAMGT 354	Entrepreneurship and Venture Capital
GSBGEN 339	Environmental Entrepreneurship	STRAMGT 355	Managing Growing Enterprises
GSBGEN 561	Sports Business Finance	STRAMGT 356	Detailed information on Creating a Startup I
GSBGEN 360	Sports Business Management	STRAMGT 359	Aligning Start-Ups with Their Market
MKT324	New Product Development	STRAMGT 366 (brief info)	Detailed Information on Creating a Startup II (Winter Quarter)
OIT 333	Entrepreneurial Design for Extreme Affordability	STRAMGT 369	Social Entrepreneurship
OIT 334	Entrepreneurial Design for Extreme Affordability	STRAMGT 370	Strategy and Action in the Information Processing Industry
OIT385	Biodesign Innovation: Concept Development and Implementation	STRAMGT371	Strategic Management of Technology and Innovation
POLECON 332	Managers and the Legal Environment		

STRAMGT 508*	Entrepreneurship from the Perspective of Women: Stanford Business Magazine article	STRAMGT 543	Entrepreneurship Through Acquisition
STRAMGT 513*	New Venture Workshop		

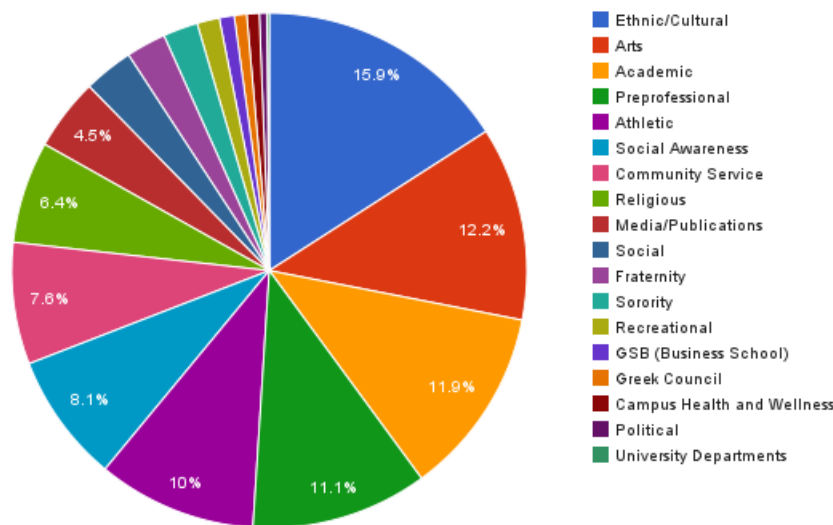
CLUBS AND STUDENT GROUPS

Clubs and student groups contribute to Stanford’s entrepreneurial habitat by providing a way for students to self-organize events, programs and initiatives to meet and bring together students interested in entrepreneurship.

Overall Student Groups at Stanford

- 641 registered Voluntary Student Organizations (VSOs) in total (as of 2011)
- VSO formation is cyclical - every year new groups are created while some groups die out
- VSO list only captures registered groups but does not reflect informal networks (such as the Stanford Entrepreneurship Network)
- There is no category that reflects social entrepreneurship but several categories could include groups engaged in social entrepreneurship ventures (especially groups classified under “Social Awareness” and “Community Service”)
- Key groups which focus on entrepreneurship, such as BASES, are classified as “Pre-professional”

VSOs at Stanford



VSOs at Stanford, Source: Stanford Student Activities and

Leadership (2012). <https://sal.stanford.edu>

BASES — Business Association of Stanford Entrepreneurial Students

In March 1996, five Stanford graduate students saw a need to expand their engineering curriculum to learn more about the process of creating new ventures. Being aspiring entrepreneurs, they started the Business Association of Stanford Engineering Students (BASES), which today serves the entire Stanford community as the center of all entrepreneurial activities, ultimately replacing “Engineering” with “Entrepreneurial” to more accurately reflect the organization.

BASES is a team of undergraduate and graduate Stanford students devoted to supporting the budding entrepreneur. Their advisory board consists of prominent professors, venture capitalists, and entrepreneurs dedicated to synergizing the worlds of academia and industry. BASES runs the Stanford E-Challenge, Stanford’s business plan competition. Stanford Entrepreneur's Challenge (E-Challenge) is an annual business model competition conducted by BASES with the purpose of developing the next generation of entrepreneurs.

The Social Entrepreneurship Challenge (Social-E) follows the structure of the E-Challenge, but is focused on companies with a clear goal of solving a pressing social issue. Nonprofit or for-profit companies that demonstrate scalable business ideas with quantifiable social or environmental impacts are encouraged to apply to the Social E-Challenge. Teams are judged on such measures as concept, market, social and environmental investment return and financial sustainability.

In 2010, Stanford added the Social-M Challenge, built on the recognition that the solutions to the most pressing local and global problems must be shaped with holistic, multi-perspective approaches. While technology and economic innovation are critical components, social innovation must play a leading role. Social-M aims to engage and excite social scientists and artists in fields like anthropology, history, sociology, psychology, music, and education. Participants partner with campus institutions to make real impact within one of three social categories: environmental sustainability, health, and civic engagement. Social-M channels the creative, entrepreneurial energy of Stanford students into University-supported initiatives.

Forge

Forge was created in 2010 as part of BASES to help student innovators and entrepreneurs. Some of the main services they provide are:

- **Funding** - Forge will provide up to \$20,000 for a team’s product development needs, without taking equity.
- **Legal** - Through its relationship with a prominent law firm Forge can help with legal problems students may face.
- **Mentor Network** - Forge will provide one-on-one access with venture capital sponsors and successful Valley entrepreneurs to guide students in the product development process.
- **Office space** – Workspace for startup teams can be provided through a Forge partnership.
- **Logistical SWAT team** - Building the next generation rocket ship time or knowledge to find the parts. A team of logistical experts is available to fulfill non-engineering needs.
- **Exit Opportunities** - At the Forge Demo Day, entrepreneurs pitch projects to VC’s and entrepreneurs.

Other student groups and clubs for entrepreneurship and venture capital:

Asia-Pacific Student Entrepreneurship Society (ASES)

ASES was founded in 2000 by a group of Stanford University engineering students to foster entrepreneurship in Asia while bridging the cultural gaps between countries in the Asia-Pacific and the United States. Today, ASES has chapters in 10 countries and more than 15 different universities. ASES' Stanford Chapter, hosts speaker series events, a weeklong international entrepreneurship conference, venture capital speed dating (part of E-week), mentorship, and alumni programs.

Chinese Entrepreneurs Organization (CEO)

Made up of Stanford students and alumni with Chinese background, the Chinese Entrepreneurs Organization (CEO) the organization's goal is to help members launch their businesses and execute growth strategies. CEO provides meaningful access to management/engineering talents, business partners, investors and successful entrepreneurs.

Society for Entrepreneurship in Latin America

The Society for Entrepreneurship in Latin America (SELA) is a student organization focused on creating and educating a network of entrepreneurs in Latin America. They have several entrepreneurship programs planned for this year including a weeklong spring summit where the top students from Latin American universities are invited to participate. SELA is an international organization of students founded at Stanford University to establish a network of entrepreneurial students throughout Latin America and the United States. SELA is primarily aimed at forging bond between students, professionals and academics interested in Latin America in order to promote development and encourage investment in the region. SELA is building chapters at universities in Argentina, Brazil, Chile, Colombia, Mexico, and El Salvador, while seeking partnership with other U.S. universities. SELA will reach every country in the Americas to facilitate mentoring, conferences, networking, and education based on entrepreneurship throughout the region.

Stanford Law & Technology Association

For over 20 years, the Stanford Law & Technology Association (SLATA) has brought together those interested in law and technology through speaker series, panels, and community activities. SLATA also promotes new uses of technology to improve the lives of students. For Stanford Law students, SLATA's popular "Lunch with the JDs" program provides a connection to practicing lawyers in intellectual property, privacy, free speech, and other related fields. "Dinner with the Profs" establishes an informal setting for students to debate emerging issues with leading scholars. SLATA also maintains several technology resources for students, including online bookstores that sponsor student benefits and a comprehensive database of course outlines.

Stanford Venture Capital Club

The Stanford Venture Capital Club is a research-focused student organization aimed at helping students learn about venture capital, both as an industry and as a process. This organization engages in an ongoing series of research projects in the areas of business, economics, and entrepreneurship. Its objectives are: 1) to perform market trends analysis and industry due diligence; 2) help VCs find entrepreneurs and emerging companies; 3) provide

outreach opportunities for VC sponsors and, 4) educate Stanford students about the VC process. SVCC consists of students from diverse backgrounds who have deep interests in venture capital and are skilled at identifying investment opportunities. The group includes students in Ph.D., Masters and Undergraduate programs, studying both engineering and business-related disciplines. SVCC also draws from a range of professional experiences in investment banking, private equity, equity research, management consulting, venture capital, laboratory research. Their combined wide network reaches top students, entrepreneurs and professors at Stanford and beyond.

Stanford Women in Business

Stanford Women in Business (SWIB) seeks to provide the women of Stanford University an opportunity to build a foundation in business and join an encouraging community of aspiring and successful businesswomen. Stanford Women in Business intends to equip young women with the tools necessary to seize their talent and succeed in the world of business. Through events and programs such as business skill workshops, leadership conferences, career exposès, and mentorship pairings, Stanford Women in Business is helping women find career direction, network with alumni and peers, and set and achieve ambitious career goals.

StartX

StartX, formerly SSE Labs incubator, is a student-initiated and student-run initiative to create an incubator and accelerator for Stanford students. Created in 2010, it selects members through a competitive process and connects them with resources like mentors and legal support. It also holds regular demo days attended by investors, press, mentors and others.

Stanford Faculty and Research Staff

Stanford has nearly 2,000 faculty members, all of whom are expected to be among the best in their fields at both teaching and research. The primary responsibility of faculty members is to further the university's academic mission. However, many Stanford faculty members are entrepreneurs, and the university grants one day per week for consulting with longer leaves on occasion to assist in technology transfer. These are relatively liberal policies regarding faculty leave time. The participation of a faculty member who played a key role in creating the technology can be crucial to the success of the business. In such situations, Stanford faculty members have taken up to two years in leave to engage in the entrepreneurial process. On returning from leave, these academics are expected to leaving hands-on management of the company to others and return their focus to university activities. They may also serve in roles such as members of scientific advisory boards.

It is not unusual for Stanford's engineering, applied science and business faculty to take leaves, found companies and then return to the university, and many faculty have been involved in founding multiple startups. Faculty who have founded companies include:

- Dan Boneh: Ingrian Networks* and Voltage Security
- David Cheriton: Granite Systems, Kealia* and Arista Networks*

- Jim Gibbons: Search Fox Inc.* and Sera Learning*
- Andrea Goldsmith: Quantenna Communications*
- Joe Goodman: ONI,* Nanoprecision,* and Optivision*
- Pat Hanrahan: PeakStream*, Pixar* and Tableau Software
- Mark Horowitz: Rambus*
- Tom Kailath: Numerical Technologies Inc.* and Integrated Systems*
- Monica Lam: MokaFive and Tensilica*
- Nick McKeown: Abrizio, Nemo Systems,* and Nicira Networks*
- Serge Plotkin: Decru Inc.*
- Abbas El Gamal: Actel, Silicon Architects, Pixim
- Ken Salisbury: SensAble Technologies

* These companies were launched with nonproprietary IP.

The quality of the faculty attracts equally impressive students. Stanford accepts about 7 percent of undergraduate applicants, with about 35,000 applying for one of the 1,600 freshman openings each year. Unique among its academic peers, Stanford has a graduate student population of 8,779 with the largest number—40 percent—enrolled in the School of Engineering (as of 2011). Acceptance rates in graduate programs vary. In 2010, for instance, the acceptance rate for all computer science advanced degree programs was 15.2 percent. The Graduate School of Business accepted 5.8 percent of applicants.

Students are allowed to take leave from their studies, but the expectation is for them to focus on completing their graduate degrees, which will afford long-term benefit and opportunity. Doctoral candidates are allowed to pursue activities other than research at the discretion of the faculty thesis adviser, who determines whether the activity will contribute to the candidate's education and its impact on progress toward the degree. About 17 percent of its undergraduates are the first in their families to attend college, and 80 percent of all undergraduates receive some sort of financial aid. In 2010–11, the university awarded about \$119 million in undergraduate aid and 314 international undergraduate students received aid from Stanford.

ACADEMIC PUBLICATIONS

From the 1930s to the time of the survey in 2011, 332,000 patents and 2.2 million publications have been generated by Stanford alumni, faculty, and staff. The publications account for approximately 4 percent of the total number of publications currently known to exist in the world.^{14,15}

¹⁴ <http://www.nsf.gov/statistics/seind10/>

¹⁵ <http://www.uis.unesco.org/Library/Documents/UNNESCOSR10-eng.pdf>

Table 9

Patents	
Patents (scaled)	332,436
Patents/individual who has at least 1 patent	12.03 %
Patents/founder	12.83 %
Patents/non-founder	11.75 %
Difference	9.20 %
Publications	
Publications (scaled)	2,186,048
Publications/individual who has at least 1 publication	25.19 %
Publications/founder	28.22 %
Publications/non-founder	24.67 %
Difference	14.42 %

Stanford alumni, faculty and staff who patent and publish have been tremendously productive over the years in these endeavors. We see that the entrepreneurs on average are not less productive due to their commercialization activities. In fact, entrepreneurs appear to be slightly more productive in both patenting and publishing, producing an average of 9.2 percent more patents and 14.4 percent more publications than non-entrepreneurs.

STANFORD RESEARCH

Stanford has shown that interdisciplinary research can coexist with a discipline-oriented model and that basic research can result in paradigm-shifting developments that change the world. Some relevant statistics from 2011:

- \$1.15 billion in sponsored research in 2010–11
- More than 5,100 active research projects
- About 9 percent of faculty belong to national academies
- One of just five U.S. universities to manage a national science lab

One example of how interdisciplinary research coexists with traditional disciplines and can produce new breakthroughs is the School of Engineering’s engineering the chemical engineering department. Stacey Bent, professor of chemical engineering, developed a prototype of the quantum dot sensitized solar cell. Bent was among the Stanford researchers who have found that adding a single layer of organic molecules to a solar cell can increase its efficiency threefold and could lead to cheaper, more efficient solar panels. Stanford’s \$1.15 billion in annual sponsored research (2011) is among the largest dollar amount for colleges and universities nationwide. The success of Stanford’s research endeavors can be traced to its culture, which emphasizes:

- hiring and retaining the world’s most gifted teachers/researchers
- recruiting and supporting talented graduate students and post-doctoral fellows
- giving faculty the freedom to pursue the most innovative research
- supporting applied multidisciplinary research centers
- providing faculty with exceptional resources and facilities

- supporting strong ties to industry

For faculty members at Stanford, teaching and research are considered inseparable. Faculty members teach the process of discovering new knowledge to students who, in turn, ask the questions and provide the impetus for pushing research further and faster. Stanford considers its research-trained graduates to be one of its best sources of technology transfer. Among the key criteria for the granting of tenure to faculty are success in publishing research findings in journals judged by academic peers and ability to teach undergraduate and graduate students. Faculty members at Stanford pursue basic research that leads to new knowledge. Through an organization unusual among colleges and universities, faculty members also pursue research through 17 multidisciplinary centers, many of which prioritize solution-oriented work.

STANFORD ACADEMIC ORGANIZATION

Stanford has seven schools: Engineering, Medicine, Earth Sciences, Law, Business, Humanities and Sciences, and Education. The university's culture and the proximity of the schools to one another support the multidisciplinary research and teaching for which Stanford is well known. Much of the university's multidisciplinary research is housed within its 17 independent laboratories, centers and institutes. The university manages the SLAC National Accelerator Laboratory on university land for the U.S. Department of Energy. Stanford researchers are considered leaders in a wide variety of engineering and science areas, including solar energy, fuel cells, chemical bonding, optogenetics, biological engineering, computer modeling of complex systems, high-performance computing, lasers, improved networking, artificial intelligence and robotics, plasmonics, nanoscale science and hundreds of other subjects. Among the many prominent independent engineering and science research laboratories, centers and institutes at Stanford are the following:

- Bio X (Stanford Program for Bioengineering, Biomedicine and Biosciences)
- Edward L. Ginzton Laboratory
- Geballe Laboratory for Advanced Materials
- Human Sciences and Technologies Advanced Research Institute
- Kavli Institute for Particle Astrophysics and Cosmology
- Precourt Institute for Energy
- Photon Ultrafast Laser Science and Engineering
- Stanford Institute for Materials and Energy Science
- W. W. Hansen Experimental Physics Laboratory

All research universities pursue multidisciplinary research. What makes Stanford different is the deliberateness of its approach. Multidisciplinary centers are independent of the traditional school-based organizational structure and report directly to the vice provost and dean of research. This model changes the research culture by allowing multidisciplinary research centers to engage faculty in pursuing early-stage ideas that might be considered risky and giving the centers greater access to resources.

Stanford is one of just five U.S. universities to operate a laboratory for the Department of Energy. The SLAC National Accelerator Laboratory, often called the crown jewel of the federal

government's R&D enterprise, explores the structure and dynamics of matter and the properties of energy, space and time—at the smallest and largest scales, in the fastest processes and at the highest energies. Many scientists at SLAC also are members of Stanford science departments. Thousands of scientists from around the world come to SLAC every year to conduct research in astrophysics, photon science, particle physics, structural biology, energy science and chemistry, among other fields.

In 2009-10, SLAC received nearly \$340 million in U.S. government funding. In 2010, the laboratory dedicated the mile-long Linac Coherent Light Source, the world's first x-ray laser facility, which has entirely transformed how scientists work at the atomic level of matter. SLAC director Persis Drell said when the LCLS opened that the new beam would “permit frontier research in a host of fields” and would be as important to some fields as the microscope was in the past. Among the labs at SLAC are PULSE, the Kavli Institute for Particle Astrophysics and Cosmology and the Stanford Institute for Materials and Energy Science (SIMES).

SIMES is a good example of multidisciplinary scientific research. The center includes physicists, materials scientists, geological and environmental scientists and chemists at Stanford and at SLAC Photon Science center. Its researchers study combinations of complex and novel materials to understand how to produce clean and economical energy with reduced environmental impacts. For instance, researchers recently confirmed the existence of a type of material—a topological insulator—that could one day provide dramatically faster, more efficient computer chips. As in the famous case of the discovery of nuclear magnetic resonance leading to magnetic resonance imaging, now a backbone of medical diagnosis, fundamental discoveries are often the basis of major breakthroughs. For example, basic materials research at SIMES led to the realization that recently discovered properties of certain materials could allow a totally new form of solar energy capture. The new process, called photon enhanced thermionic emission, uses both the thermal and photonic energy in sunlight, opening up the possibility of a 50 percent increase in the efficiency of solar energy capture. Faculty embrace such opportunities to see their research have transformative effects and often form new collaborations to exploit them.

FROM SCIENTIFIC RESEARCH TO COMMERCIAL PRODUCTS

There is no single path by which basic or even applied scientific research enters the marketplace as a commercial product. For the most part, university research is pursued because of the intrinsic interest in the problems tackled. This interest is sometimes, though not always, motivated by a practical problem whose solution will have obvious commercial application. One benefit of close ties between industry and the university—ties that are enhanced through faculty consulting and industrial affiliate programs—is that faculty researchers become sensitized to some of the most difficult and basic hurdles faced by their industry partners. Industry can be a wellspring of scientifically challenging and fascinating questions—indeed the entire field of chemical engineering originated from problems inspired by the early petroleum industry—but such questions do not easily penetrate an ivory tower. This is why Stanford takes pains to ensure a high-bandwidth interaction with industrial partners.

The process of commercialization of research begins with a basic discovery or invention. When a researcher makes a discovery, an important first step in the commercialization process is that he or she recognizes that the discovery may have commercial impact. It is surprising how often this does not happen, and, again, it highlights the importance of two traits characteristic of Stanford faculty: Their awareness of relevant industrial needs and their entrepreneurial spirit.

When the commercial potential of a discovery is recognized, the researcher files an invention disclosure with the university's Office of Technology Licensing (OTL). If the office judges that the discovery is both patentable and has commercial potential, it assists the researcher through the process of filing for a patent. The next judgment is whether the optimal route to commercialization is through licensing the invention to existing companies or through a startup company that can further develop the technology into a product or products. This is a crucial decision, and is usually based on a combination of characteristics of the technology itself and the entrepreneurial inclinations of the inventors.

If the decision is made to license the invention, information about the technology is circulated to likely licensors. Even when an invention is licensed to an existing company, it is often the case that effective transfer of the technology requires personal interaction between the company and the researchers involved in the invention. This can occur in the form of corporate visits to the lab, consulting by the faculty member, or hiring graduates who worked on the technology while they were students. Technology transfer rarely occurs by tossing papers or patents over the walls of the ivory tower. If the decision is made to form a startup to commercialize the invention, initial funding, often from angel investors, must be raised. To successfully navigate the early company formation stage, it is critical to receive helpful advice and mentoring from individuals who know the process and have been through it themselves.

Stanford's many faculty and alumni entrepreneurs are generous in providing this assistance to both students and faculty. Stanford's entrepreneurship courses also provide important insights into the process. To undertake the startup process, the faculty or students involved are generally required to take leaves from the university. After the company is started, it will generally obtain venture funding to allow it to grow and to give it time to develop the basic invention into products. If it is successful, the company will then either be acquired or reach IPO stage. By this time, it is generally the case that the faculty member has returned to Stanford but continues in a consulting role with the company.

A Stanford University report prepared for New York City in 2011 cites the example Mango Materials, a company devoted to creating biodegradable composites for the building industry, as an example of a transition from an early research idea to a startup company. In 2004, a team of environmental and engineering researchers was awarded a small two-year seed research grant from Stanford's multidisciplinary Woods Institute for the Environment. Seed grants of this sort are given by most of Stanford's interdisciplinary labs to encourage exploratory projects that bring together multidisciplinary teams who have not worked together before. The grant in question was to develop artificial wood that is both durable and recyclable. The research team focused on a new class of construction material called biodegradable composites—glue-like resins reinforced with natural fibers that are made from plants and recyclable polymers.

In 2008, the team's work moved beyond artificial wood products, and it was awarded a three-year, \$1.5 million grant from the California Environmental Protection Agency to develop biodegradable plastics to replace the petrochemical plastics used to make disposable water and soda bottles. In 2009, after securing appropriate patents, Molly Morse, a Stanford PhD working on the project, founded Mango Materials to transfer the technology to market. The goal of the company is to help diminish the amount of landfill by producing biodegradable plastic from waste biogas.

Stanford's experience has been that the most successful research is done by entrepreneurial faculty members fueled by intellectual passion and curiosity, but with a deep awareness of the

real-world implications of their research, whether those implications are commercial or otherwise. Stanford is committed to having its research benefit the world, and to making its findings open and accessible. For this reason, Stanford does not do classified or proprietary research.

SUCCESS OF FUNDED RESEARCH

The most common metric to evaluate research, both at Stanford and elsewhere, is publication of articles in peer-reviewed journals. The most common measure of research impact is citations to journal articles. According to the Institute for Scientific Information citation database, from 2003 to 2007, Stanford faculty published 25,633 papers that were cited 266,961 times, the second highest citation total for this period. Following are four examples of successful sponsored research whose results were published in 2011; some of the work is ongoing or even open-ended; some may lead in new, unexpected directions; and some may lead to relatively early discoveries or inventions.

- In August 2011, a team of Stanford and Harvard researchers announced in the journal *Nature Communications* that they had developed a new organic semiconductor material that is among the speediest yet. The research was supported by the Stanford Global Climate and Energy Project, Netherlands Organization for Scientific Research, National Science Foundation, King Abdullah University of Science and Technology, Air Force Office of Scientific Research, Harvard Materials Research Science and Engineering Center, the Camille & Henry Dreyfus Foundation and the Sloan Foundation.

- In August 2011, Stanford physicists announced that they had developed new methods to detect emerging sunspots deep inside the sun, warning of dangerous solar flares. The research, supported by NASA, was reported in the journal *Science*.

- In August 2011, electrical engineers at Stanford announced in the journal *Neuron* that they had used new neurological measurement technologies and new analytical mathematics to better understand the processes behind the way the brain plans and executes motion. The project was supported by the Collaborative Research in Computational Neuroscience program, a joint initiative of the National Institutes of Health and the National Science Foundation. It is an example of how computer science is evolving in the context of biomedical research.

- In July 2011, Stanford engineers demonstrated a new nanoelectronic device that emulates human synapses, the brain's computing mechanism.

Stanford Internal Entrepreneurial Ecosystem: The Office of Technology Licensing

For many decades the Stanford Office of Technology Licensing has been a leader among the country's universities in licensing technology, particularly to startup firms. Established in 1970, the mission of the Office of Technology Licensing is to promote the transfer of Stanford technology for society's use and benefit while generating unrestricted income to support research and education.

Year	Notable Stanford Inventions	Value in Millions of \$
1970	OTL Established	
1971	FM Sound Synthesis	\$22.9
1974	Recombinant DNA	\$255
1981	Phycobiliproteins	\$46.4
1981	Fiber Optic Amplifier	\$48.4
1981	MINOS	\$4.0
1984	Functional Antibodies	\$279
1987	Selective Amplification of	\$16.9
1990-92	Polynucleotides	\$29.1
1994	Discrete Multi-tone technologies	\$6.5
1996	for DSL	\$337
	In vivo Bioluminescent Imaging	
	Improved Hypertext Searching - Google™	

COMPANY FORMATION: TECHNOLOGY TRANSFER

In 2010, Stanford’s OTL celebrated its 40th anniversary — four decades of success, 8,000 inventions and approximately \$1.3 billion in royalties earned for the university. According OTL, Stanford’s technology transfer process is comprised of the following steps:

- The inventor submits a disclosure form to Stanford’s Office of Technology Licensing (OTL) describing the invention and naming inventors and sponsors.
 - After the disclosure is logged and assigned a docket number, an associate is assigned who will manage the docket “cradle to grave.”
 - The inventor meets with the assigned OTL associate, who evaluates its feasibility, potential applications and possible markets and subsequently develops a licensing strategy.
 - OTL determines if the invention is a candidate for patent application. Among the factors that determine if the invention is a candidate: its novelty, competing technologies, protectability and marketability of potential products or services, the size and growth potential of the relevant market, resources required for development and potential competition.
 - Concurrently, the associate will market the invention. When Stanford markets the invention, it looks to its many existing businesses, as well as to newer startups. If successful, the associate begins negotiations for licensing. After a license agreement is signed, the licensee’s performance is monitored by OTL for the duration of the license and may amend the agreement over time.

Over the course of the agreement, many licensees continue to develop the invention to enhance the technology and satisfy market requirements. Most agreements require performance milestones and periodic financial and development reports to Stanford. OTL audits licenses for compliance and diligence reporting requirements and meets with licensees often. If milestones are not met or other problems surface, OTL meets with the licensee to see how it can be resolved.

- OTL collects all royalties and distributes them at the conclusion of each fiscal year (Aug. 31). Fifteen percent supports OTL's operation costs, and net royalties are divided by thirds: one-third goes to the inventor(s); one-third to the inventor's department; and one-third to the inventor's school, e.g., School of Engineering, School of Medicine, etc. Royalties distributed to Stanford (school and department) are used for research and educational purposes.

- OTL may choose to accept equity in addition to cash as part of the license issue fees. The decision to accept equity or royalties is based on negotiations with the company. If equity is chosen, the equity holdings are managed by the Stanford Management Company and earmarked for the Dean of Research and the Vice Provost for Graduate Education.

OTL STAFFING AND OPERATING BUDGET

There are currently 37 staff members at OTL, including nine licensing professionals responsible for managing inventions. The staff, which is responsible for more than 3,000 active dockets, has combined experience that exceeds 300 years in technology transfer at Stanford and 475 years of cumulative applicable experience. All OTL licensing associates have degrees in science or engineering. In fiscal year 2010-11, OTL's operating budget was \$5.4 million and patent expenses were approximately \$7 million. The operating budget has increased steadily in recent years; in fiscal year 2005-06 it was \$3.76 million.

Katharine Ku is the director of Stanford's Office of Technology Licensing, a position she has held since 1991. A chemical engineer and inventor, Ku has been active in the Licensing Executives Society, serving as vice president, and trustee and chairing various committees. She also has served as president of the Association of University Technology Managers (1988-90) and received the AUTM 2001 Bayh-Dole Award for her efforts in university licensing. She was a member of the National Academy of Sciences committee that issued the 2010 report titled "Managing University Intellectual Property in the Public Interest." She is the secretary of the Certified Licensing Professional Board of Directors. Ku earned her bachelor's degree in chemical engineering from Cornell University and her master's in chemical engineering from Washington University in St. Louis and worked in industry in the 1970s. She is a registered patent agent.

Stanford's philosophy on licensing revenues versus equity is to commercialize proprietary technology by licensing it to the best possible licensee, whether that is a startup or an existing company, according to a Stanford University report prepared for New York City in 2011. The "best" licensee is a company in which there is a champion with a vision and resources to develop the technology. Stanford is neutral about whether financial returns are in the form of equity or earned royalties, and the decision is based on negotiations with the licensing company. Historically, Stanford has generated more revenue from earned royalties than from the equity. Although Google was Stanford's biggest equity cash-out at \$335 million, the remaining equity liquidations add up to approximately \$30 million out of \$1 billion in cumulative earned royalties. Additionally, Stanford sells its shares as soon as liquidation is possible rather than trying to maximize return on equity. For conflict-of-interest reasons, if a company in which the university has equity conducts a clinical trial at Stanford, the university will divest itself of the equity and earned royalties as appropriate.

FUNDING FOR TECHNOLOGY STARTUPS

Stanford does not track or maintain information about external funding received by individuals for startups. In recent years, the university has invested in companies that have licensed technology from OTL. License agreements to startups stipulate that Stanford can buy more equity in subsequent rounds (post-licensing), but any proceeds are considered investment proceeds rather than licensing revenue. These equity investments in technology transfer companies are made through a university fund called the President's Venture Fund. Stanford makes these investments when a company is raising money from the venture capital community (or from other professional investors). It continues to support these companies as they raise additional funds. The President's Venture Fund does not award grants. It provides early-stage funding—prior to breakeven, acquisition or IPO—and has included both seed rounds and Series D funding. As of March 31, 2011, the four-year-old President's Venture Fund had invested in 28 companies. Total invested capital as of March 31, 2011 was more than \$21 million in both preferred stock and convertible notes, with investments ranging in size from \$600,000 to \$5 million per company. The rate and size of Stanford's investment is primarily dependent upon the rate at which OTL licensees complete qualifying fundraising activities and has steadily increased each year.

IMPACT OF TECHNOLOGY TRANSFER ON TENURE REVIEW AT STANFORD

All tenure decisions are based on excellence of scholarship, service and teaching. Although Stanford does not consider technology licensed or patents issued during its review of appointments and promotions of faculty, technology transfer is encouraged by the university. The impact of a faculty member's research and contributions is measured in various ways, including its impact on other research and advances to a field of knowledge.

BEST PRACTICES RELATED TO STANFORD'S TECHNOLOGY TRANSFER PROCESS¹⁶

Best Practice No. 1:

Keep the technology transfer process close to the faculty. OTL reports to the dean of research, on the academic side of the university, rather than to business affairs. This keeps the technology transfer process as close to the faculty as possible, a practice considered fundamental in supporting effective technology transfer.

Best Practice No. 2:

Transfer new technology to as many companies as possible. OTL's goal is to "plant as many seeds," i.e., transfer new technology to as many companies as possible, and one of its internal measures of success is the number of licenses concluded annually. Some technologies will flourish, others will not, but that is for the marketplace to determine.

¹⁶ Compiled by Stanford in 2011 for a New York City campus proposal.

Best Practice No. 3:

Negotiate agreements with long-term relationships in mind. Flexibility has played a big role in OTL's success, and each agreement is negotiated with the licensee's circumstances in mind.

- Licensing associates are given considerable autonomy to make patenting decisions and to negotiate creative licensing arrangements based on the unique circumstances of the particular individual technologies and licensees.
- Associates draft their own agreements in plain English that both expedites license negotiation and sets the tone for a long term relationship with the licensee. The director has the authority to sign all license agreements without prior legal review. OTL's goal is to build strong working relationships between the university and industry, so the spirit of the agreement and the relationship between the parties are almost more important than the actual contract.
- Since a license is often in existence for 20 years, during which many unexpected events happen, OTL works with its licensees to change the licenses as circumstances change.

Best Practice No. 4:

Improve access to information for staff and inventors to expedite technology transfer. OTL has also developed infrastructure within its office to streamline operations, improve communications and enable remote access to the office for staff and inventors. Notable examples are:

- TechFinder portal, where individuals can search for available technologies or sign up to be notified of new inventions.
- OTL's Researcher Portal which allows faculty to review the status of their industry sponsored research, material transfer and collaboration agreements and gives all inventors access to their invention, marketing, patent and royalty distribution information
- A robust customized database for staff to manage inventions and relationships with inventors, companies and colleagues both in the office and remotely (including outsourcing some activities to employees working in other cities)
- Web-based invention disclosures
- Digital signatures for license agreements and ready-to-sign license agreements with the capability of receiving credit card payments

Best Practice No. 5:

Encourage collaboration with other institutions by minimizing use of material transfer agreements (MTAs). Material transfer agreements are contracts governing the transfer of research property. In 2010 Vice Provost and Dean of Research Ann Arvin issued a letter to faculty to minimize the use of MTAs. This reduced barriers to research collaboration at other academic or nonprofit institutions or in industry. This has had national impact as other institutions have adopted Stanford's practice.

Best Practice No. 6:

Manage the licensing process to lessen potential conflicts of interest. OTL works with Stanford faculty both to facilitate technology transfer and to manage the licensing process. To mitigate conflict-of-interest concerns, OTL markets inventions broadly does not allow inventors to negotiate on behalf of the company, does not offer more favorable terms to spin-off companies and does not actively participate in fundraising or new company formation. Nevertheless, OTL is able both to navigate conflict-of-interest issues and to successfully license startups.

Best Practice No. 7:

Facilitate the licensing of Stanford engineering inventions to high-tech companies. In 2000, OTL used input from industry to create the Engineering Portfolio of Inventions for Commercialization (EPIC) program to facilitate licensing Stanford engineering inventions to large high-tech companies. Offered broadly to electronic firms, EPIC made IP issues in sponsored research contracts easier to negotiate. Hewlett Packard and Intel were enthusiastic participants in this five-year program, with both companies taking licenses.

Best Practice No. 8:

Assist other nonprofit organizations with licensing, Stanford has established a separate, wholly owned limited liability corporation (Stanford OTL-LLC). Many nonprofit organizations do not have the resources or expertise to establish their own formal technology transfer office and turn to Stanford for assistance. Stanford OTL-LLC was established to extend Stanford's expertise and allow OTL to act as a licensing agent for nonprofit organizations.

Evidence that these best practices have resulted in OTL becoming a nationally recognized and innovative leader in technology transfer:

- In 2010, David J. Kappos, the U.S. undersecretary of commerce for intellectual property and director of the United States Patent and Trademark Office, marked OTL's 40th anniversary with a letter of congratulations, writing: "You are truly the gold standard of technology transfer office ..."
- In 2006, Stanford received the inaugural award from the International Marketplace & Conference for Technology Transfer Professionals for its outstanding achievements in developing technology transfer and licensing on an international scale.
- In 1999, the Licensing Executives Society awarded OTL its inaugural Achievement Award in recognition of OTL's outstanding contribution to licensing or other technology transfer activity.

RESULTS OF STANFORD'S TECHNOLOGY TRANSFER PROCESS

The success of Stanford's approach to technology transfer is evidenced in many ways. OTL reports that it receives an average of eight or nine new disclosures each week. Patent applications are filed on about 60 percent of the disclosures, and OTL licenses about 25-30 percent of the inventions. In 2010, OTL received more than 450 new technology disclosures, of which approximately 40 percent were in the life sciences and 60 percent in the physical sciences, including computer science technologies and medical devices. In fiscal year 2010-11, Stanford received \$66.8 million in gross royalty revenue from 600 technologies, with royalties ranging from \$1.80 to \$44.12 million. Thirty-two of the 600 inventions generated \$100,000 or more in

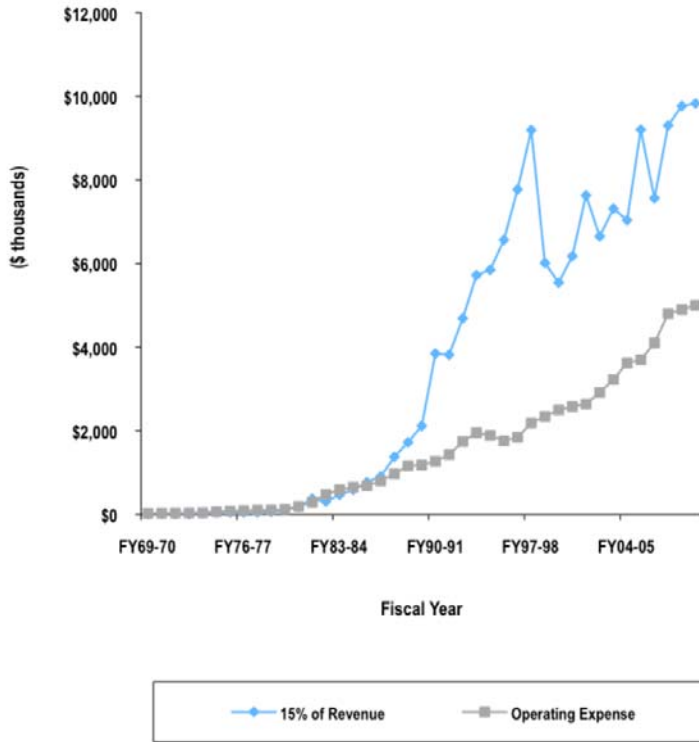
royalties; six inventions generated \$1 million or more. The average annual revenue in fiscal years 2005-06 through 2009-10 was \$61 million, which includes an average of \$1.3 million per year from the liquidation of equity. OTL evaluated about 504 new invention disclosures in calendar year 2011 and concluded 101 new license agreements. In fiscal year 2009-10, OTL concluded 90 license agreements, including 10 with equity. The average over fiscal years 2005 through 2010 was 92 new licenses per year, including 10-11, with equity each year. Since its establishment until 2011, OTL has taken equity in some 190 companies.

Just as there are many paths to launching non-proprietary startups, there are several classifications for startups launched through the technology transfer process at Stanford. According to OTL, these break down as follows:

- Startups based on Stanford technology that have been through a formal OTL process. Examples include Google, MIPS, Amati, SGI and Sunpower. All had licenses from Stanford and used core technology.
- Startups based on Stanford-inspired and related technology, which may or may not have licenses. Examples include VMWare (related/licensed), Atheros (related/licensed), Sun and Abrizio. In addition to the success stories provided, there are many companies that are not household names but reflect the breadth and depth of Stanford's culture of innovation:
- Brion Technologies is a leader in computational lithography and has automated methods to detect defects in patterns for use in industries ranging from semiconductors to oil. Stanford electrical engineering professor emeritus Fabian Pease is one of Brion's co-founders.
- Coverity provides a portfolio of software testing products to detect errors in computing systems. Dawson Engler, associate professor of computer science and of electrical engineering, is among Coverity's co-founders.
- iRhythm has developed a multidisciplinary solution to monitor cardiac rhythms. Its inventors come from Stanford's program, schools of business and engineering.

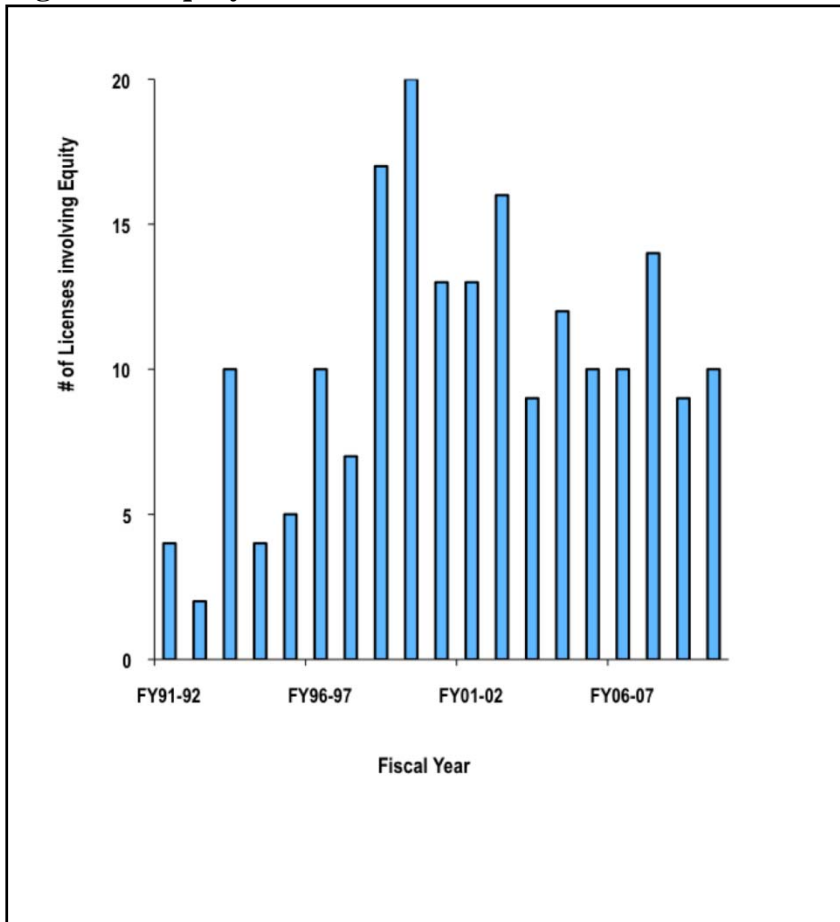
From 1970 through 2010, approximately \$1.33 billion cumulative royalties were generated. Typically, 10 to 15 years may elapse between initial invention disclosure and any significant royalties. In FY09-10, \$65.5 million was generated from 553 disclosures. The distribution of outcomes from these technologies is highly skewed. A total of 32 out of 553 disclosures generated over \$100,000 each, 2 out of those 32 generated over \$1 million each. From 1970 through 2010, a total of 66 inventions generated \$1 million or more in royalties. Only 3 out of 8,000 disclosures over that time frame have generated truly significant revenues. Note that the figures below do not include royalties from the hypertext searching patents from Google.

Figure 39 Royalties Generated Through OTL



Stanford’s OTL is self-supporting as 15 percent of revenue is greater than its operating expenses. The operating budget is approximately \$5.0 million per year. The patent expenses total ~\$7.1 million per year. OTL has given ~\$45.2 million to the Research Incentive Fund administered by the Dean of Research. The OTL has given ~\$14.4 million to the Research & Graduate Fellowship Fund.

Figure 40 Equity from Licenses



Stanford’s philosophy is that equity is one component of a whole financial package. Historically, most income is generated from earned royalties (~\$965 M vs. ~\$365 M). Equity is liquidated soon after IPO. Stanford can’t hold equity if licensee conducts clinical trials here.

Over time, the OTL has held equity from licenses in ~190 companies cumulatively, and ~105 companies currently. The equity liquidated as of 2011 is ~\$365.5 million, not including Google. A few examples include Amati (now part of Texas Instruments) \$8.0 million, Abrizio (PMC-Sierra) \$9.7 million, and Google™ at \$336 million. The typical equity distribution is –15 percent to OTL, 1/3 of net equity to the inventors, 2/3 of net equity to the OTL Research and Fellowship Fund. The types of License Agreements include an option agreement, a non-exclusive agreement, or an exclusive agreement. These are typically limited by field of use, and period of time (e.g. earlier of 8 years from effective date or 5 years from first commercial sale).

Figure 41

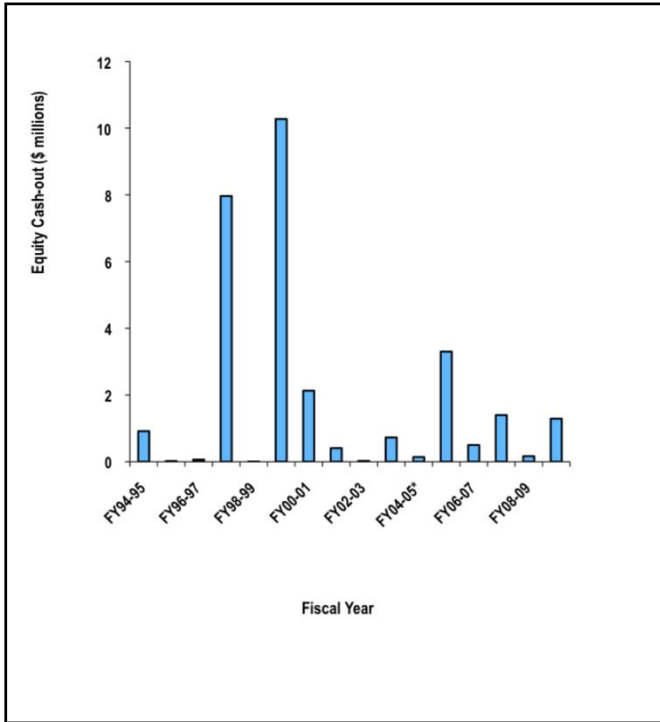


Figure 42

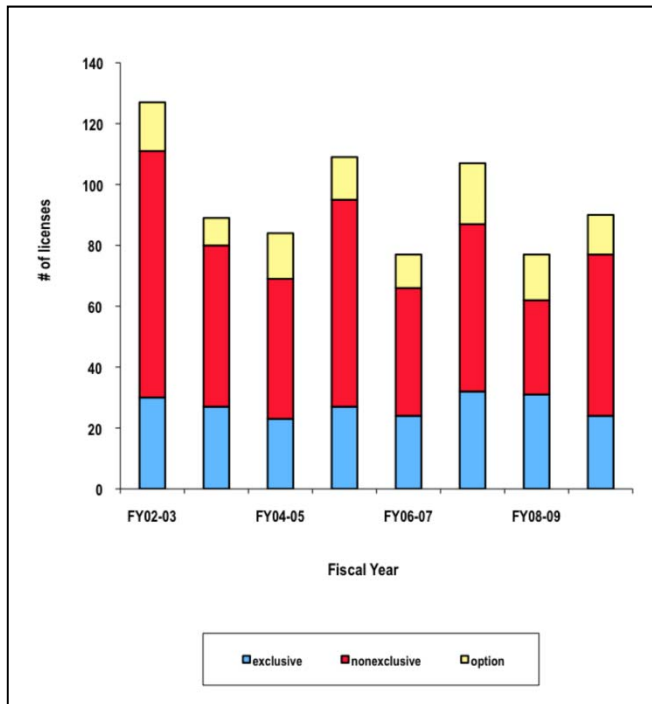


Table 10

Number of Spin-off companies created from the OTL or University Research	Non Bio Sci	Bio Sci
2006-2010	2528	242
Average number of employees per spin-off	93	70

Number of Patents Obtained	Non Bio Sci	Bio Sci
Average per firm from 2006-2010	1.2	2.7
Average per firm for firms founded in 2005	2.3	5.2
Total over the past 5 years	8737	224
Total for firms founded in 2005	1747	45

BUSINESS EXPANSION/ATTRACTION/PARTNERSHIPS

Stanford partners with industry and businesses to identify challenges and transform research into real-world applications. Through these partnerships, technologies are developed that meet real-world needs, and the university facilitates the transfer of new knowledge for the public good. Industry is interested in generating ideas that will meet needs, in working in a low-risk environment to test those ideas and in identifying great employees. Stanford is an ideal partner in this effort. The university provides a venue for testing ideas and engaging in high-risk research—the kind of research that has the potential to transform industries—and offers many programs that encourage and support businesses in these efforts. This approach is based on Terman’s model of the modern research university developed in the mid-20th century and has evolved with time to keep pace with new research discoveries, new technologies and new markets for those technologies. Stanford enables this in very specific ways:

- Visiting scholars from industry are encouraged to spend time in campus research groups, working closely with researchers. Industry experts frequently come to campus as speakers, lecturers, consulting professors and project coaches.
- Tenure-line faculty members are at the core of research, and industry and related experts make important contributions with their information, experience and direct interaction with students.
- Industrial affiliate programs bring industry and university experts together around topics of mutual interest and act as networking and recruiting platforms.
- The university maintains focused research centers; a balanced portfolio of financial support from the federal government, foundations, industry and individuals; and continuing business and engineering education.

Stanford’s Career Development Center (CDC) also hosts 13 career fairs each year.

Participation ranges from 15 to 300 employers—some fairs are open to all employers, while others target specific areas such as product design, civil engineering or medical devices. There is also one job fair each year devoted to diversity. The 2011 Fall Career Fair attracted 301 employers—175 of which were Bay Area companies.

Stanford's culture is one of collaboration and innovation, and it has developed practices specifically designed to encourage students and faculty to work directly with companies whose interests dovetail with the university's. At its most basic, technology transfer involves the transfer of ideas and individuals with knowledge of the technology. A concrete example of the power of this transfer: in fiscal year 2009-10 approximately 20 percent of all engineering research was funded by industry through sponsored research, affiliate programs and gifts.

Stanford's affiliate programs are a vehicle for a two-way cultural change. The university's more than 50 affiliate programs and research centers are found throughout the university: Some are housed in departments, others are thematic, but all act as a first step toward deeper research relationships between business and university. Through affiliate programs, which require the participation of at least two faculty members and two companies, students can work closely with corporate executives and research scientists. In turn, these exchanges provide businesses with a forum for high-level discussions about trends and access to emerging research and talented students. Examples of affiliate programs and centers include:

- The Center for Integrated Systems, which develops complex semiconductor, electronics and computer systems in the context of real world applications and has partnerships with more than 20 leading global companies.
- Computer Forum, with more than 80 participating companies.
- Clean Slate Design for the Internet, whose mission is to “reinvent the Internet” and which works with 10 members including Google, Cisco and the National Science Foundation.
- The MobiSocial Laboratory, which works on open, mobile Internet use with the collaboration of AVG, Google, ING Direct, Nokia and Sony Ericsson Mobile Communications.
- Global Climate and Energy Project (GCEP)
- Hasso Plattner Institute for Design (d.school)

Collaborative research and a more general collaborative culture are also enabled through specific private-sector contracts and gifts. Over the past decade, Stanford has seen a steady increase in corporate support of engineering through gifts and contracts. This has given the university's research portfolio more balance across funding sources and greater stability against the vagaries of federal funding cycles. Gifts frequently support graduate research, often providing the seed funding for high risk/high reward ideas that—once proven—have earned significant federal research funding. In addition to directly funding research, many of Silicon Valley's legal and venture capital firms provide targeted gifts as a way of gaining visibility and recognizing Stanford's contributions to their portfolio companies.

In addition to their corporate support, founders of prominent local companies—such as David Packard, William Hewlett, Phil Knight at Nike, John Arrillaga, Helan and Peter Bing, Jerry Yang at Yahoo!, James Clark at Netscape, Lorry I. Lokey at Business Wire, Jen-Hsun Huang at NVIDIA, and many others—have been exceptionally generous. Others, such as Hasso

Plattner, co-founder of SAP and major donor to the Hasso Plattner Institute of Design at Stanford, envision their gifts as a way of influencing the course of industry and education.

Stanford offers a variety of services designed to link faculty and students to businesses. Faculty, students, researchers and industry practitioners develop long-lasting mentoring relationships in the course of their collaborative work. Some of these arise through affiliate programs:

- The Center for Integrated Systems has a Fellow Mentor Advisor program that matches top graduate students and faculty members with outstanding researchers from industrial partners.
- Visiting research scholars. Companies frequently send individuals from their research organizations to spend one to three quarters working closely with a Stanford research group. These visitors bring industry insight to the lab, but also build lasting relationships with the faculty and students that extend beyond the visit.
- Research centers. Centers such as the Global Climate and Energy Project (GCEP) provide formal forums for review and funding of research, as well as opportunities for exchange of ideas and mentoring of students.

SRI International

SRI International is an independent, nonprofit research institute conducting client-sponsored research and development for government agencies, commercial businesses, foundations, and other organizations. SRI also brings its innovations to the marketplace by licensing its intellectual property and creating new ventures.

Founded in 1946 as the Stanford Research Institute by a group of West Coast industrialists and Stanford University. SRI formally separated from the university in 1970 and changed its name to SRI International in 1977. For 65 years, its strengths have been the staff's world-leading expertise and passion for working with clients on important challenges. SRI is well known for its legacy of innovations in communications and networks, computing, economic development and science and technology policy, education, energy and the environment, engineering systems, pharmaceuticals and health sciences, homeland security and national defense, materials and structures, and robotics.

INCENTIVES SUPPORTING EXISTING BUSINESSES

Stanford offers many programs that encourage and support industry. Some are student-organized, some are driven by individual faculty members, and some leverage the interdisciplinary work of faculty and students. The university is also a powerful draw for venture capitalists, attracted to the range and variety of programming. Farsighted companies find that the relationships that develop in providing support to entrepreneurial faculty can invigorate their own employees' creativity and bring significant and unexpected insights into their business. Unrestricted gifts support faculty as they explore high-risk ideas. It also gives businesses the opportunity to meet and recruit talented students engaged in nontraditional research. Sponsored research gives corporations the opportunity to support more focused efforts.

Global Climate and Energy Project (GCEP) is one example. As the global demand for energy has continued to increase in recent years, it is clear that there is no single solution and that it will

require the engagement of the best scientific minds around the world working on a variety of fronts. Established in 2002, GCEP is engaged in a broad portfolio of pre-commercial research in potential solutions with support from four international companies: ExxonMobil, General Electric, Schlumberger and Toyota.

As of 2011, GCEP has launched 75 full-time research projects at 30 institutions worldwide. Challenges range from developing advanced fuel cell systems to carbon capture and storage and high-efficiency photovoltaic cells. These are complex issues, and an important part of this work is sharing what has been learned. Since its inception to 2011, 32 applications for patents have been filed and findings shared with colleagues through 292 peer-reviewed publications and 429 presentations at professional conferences. Many of the projects started with small seed grants and have since developed proof-of-concept findings that have earned them much larger federal support.

The companies involved clearly have an interest in moving this kind of research forward. Their scientists and engineers have the opportunity to work side-by-side with Stanford faculty and students. They also have an interest in engaging with each other in high-level discussions about their industry. And of course, there is always the possibility of hiring talented students. Stanford benefits from these discussions, as well. The exchange of information and perspective with industry helps advance understanding of today's enormous challenges. It also provides excellent preparation for a cadre of new engineers and scientists poised to continue the work in academia and industry

Best practices in creating collaborations and partnerships:¹⁷

Best Practice No. 1:

Match research interests with the long-term needs of the marketplace. Stanford's most distinctive best practice in working with existing businesses is its organic approach that is internally sensitive to the interests of research colleagues and externally responsive to the needs of the marketplace. Partnerships and relationships transform and evolve as needs change and new interests arise. Ten years ago, when Cisco was smaller and 3Com was an important industry player, the Networking Research Center played a key role in bringing university researchers and industry experts together. Today the Networking Research Center does not exist. Needs and technology have evolved, and now Cisco is one of 10 members—along with Google, Docomo and the National Science Foundation—of the Clean Slate Design for the Internet, which is rethinking the way information is sent. It is headed up by Nick McKeown, professor of electrical engineering and computer science.

Best Practice No. 2:

Strong affiliate programs. Stanford's affiliate programs are among its best practices in supporting existing business and developing collaborative research partnerships. A key element in the affiliate programs is ensuring that faculty and students are aware of real-world conditions and needs. Over 60 programs spread throughout the university provide avenues for industry to access research, get to know participating faculty and have opportunities to recruit talented students. Examples include the Design Group, which houses two affiliate programs: Industry

¹⁷ Compiled by Stanford in 2011 for a New York City campus proposal.

Affiliate for Teaching Design Thinking and the Center for Automotive Research at Stanford (CARS).

Best Practice No. 3:

Provide R&D opportunities for industry in university labs. Some types of research can only be conducted in large laboratories such as are available at research universities. Stanford provides access to some of its labs through memberships to academic, government or industrial organizations for research and development activities, broadly defined.

The Stanford Nanofabrication Facility (SNF) is one example. Nanoscale research has the potential to advance many technologies—fuel cells, medical imaging and electronics—but it requires very expensive and sophisticated equipment. The SNF was designed as a “sandbox” to provide lab members the opportunity to work with equipment rarely available to researchers in small companies. Members can work on-site or remotely. A suite of software tools, training on equipment and skilled personnel are available to help industry researchers effectively use the SNF.

Working with industry is also fundamental to the mission of the SLAC National Accelerator Laboratory, operated by Stanford for the U.S. Department of Energy.

GROWTH OF BUSINESSES AS A RESULT OF COLLABORATION

The list of companies that have developed strong relationships with Stanford is long. Many of the world leaders in technology have links to the university, and their research connections over the years have been complemented by generous gifts and contracts. Technology developed at the university has found its way to the world’s leading technology firms. The relationships nurtured over the years have proven mutually beneficial for business and for the university.

The primary benefit companies gain from collaboration and close ties to Stanford is access to its outstanding graduates. For companies to grow and compete, they need excellent and innovative employees, and they have turned to the university for their talent. Top local companies that have hired Stanford students in technical, management and leadership roles over the past decade include Oracle, Yahoo!, Facebook, LinkedIn, Zinga, Pixar, Tesla, IDEO, eBay and Cisco. Google has benefited from its relationship with Stanford. It estimated that 1,300 of its employees are Stanford alumni. And as noted in the General Entrepreneurship subsection, the company has licensed Stanford inventions, acquired university spin-offs and hosted Stanford faculty engaged in research.

BUSINESS RELOCATION AS A RESULT OF COLLABORATION

The Stanford Research Park is a strong magnet. Bosch, Volkswagen, SAP and General Electric have established research and development groups in the Stanford Research Park specifically to develop closer ties to Stanford faculty and students. While not all are known as information technology companies, their businesses increasingly rely on developing new technologies for communications, manufacturing efficiencies and consumer products that are dependent on information technology. Each has a robust and constantly evolving relationship with the university.

Two companies illustrate the breadth and depth possible. Volkswagen opened its Electronics Research Laboratory in Palo Alto in 1998. It has collaborated with the Stanford Racing Team, then led by Stanford computer science Professor Sebastian Thrun, in developing robotic cars. In 2005, Stanley, a modified Volkswagen Touareg, won the DARPA Grand Challenge by navigating 132 miles of Nevada desert; in 2007, Junior, a modified Volkswagen Passat, placed second in DARPA's Urban Challenge, a course through simulated city traffic. In 2009 Volkswagen subsequently helped establish the Volkswagen Automotive Innovation Lab (VAIL) on the Stanford campus. Volkswagen partnered with Bosch, Honda, Toyota and Nissan in the Center for Automotive Research at Stanford (CARS).

Robert Bosch GmbH opened its Palo Alto Research and Technology Center in 1999 in the Stanford Research Park. It deliberately located its new center near Stanford so that their scientists and engineers could work closely with the Stanford faculty and students on a variety of topics. Bosch headquarters are located in Germany and it operates in the areas of automotive and industrial technology, consumer goods and building technology. Bosch's Research and Technology Center focuses on networking, information technology and manufacturing design. In addition to being an active partner in the DARPA Challenges noted above, Bosch has built partnerships through the Stanford Network Research Center, the Center for Integrated Systems and the Computer Forum. It has supported multiple research projects and design courses with both funding and dedicated research and teaching mentors from its organization. In addition, it has provided more than \$6 million in endowment in support of faculty and students. Since the opening of the office, Bosch has employed Stanford interns, successfully recruited several recent graduates and leveraged research and technology insights developed at Stanford across its company.

Conclusions: Enhancing the Role of Research/Technology Universities in Innovation and Entrepreneurship

Stanford encourages and sustains its culture of innovation and entrepreneurship through programs that build a creative spirit, but also draw people to the university who have this creative, entrepreneurial spirit within themselves. Stanford is a center for creative thought and experimentation and this includes innovation in companies, non-profits and in the humanities and creative arts. It plays an important role in attracting and retaining talent as well as building a highly skilled workforce in the Silicon Valley region.

Appendix: Sources of Information

COMPANY DATABASE

ALUMNI SURVEY

ESTIMATION METHODS

STANFORD UNIVERSITY 2011 INNOVATION SURVEY

In 2011, Charles Eesley, Assistant Professor of Management Science and Engineering in Stanford's School of Engineering, conducted a survey of 142,496 individuals—all living Stanford alumni, current faculty and selected (research) staff—to explore the influence of education on life and career choices. Responses were received from 27,780 individuals, for a response rate of 19.5 percent. The response rates were similar across gender, departments and graduation year.

Below are the rates broken out by gender and school. These numbers are the percentage of respondents out of the total number in that category who received the email.

Women: 19%

Men: 19%

Business: 23%

Earth Sciences: 30%

Education: 30%

Engineering: 22%

Law: 20%

H&S: 13%

Medicine: 27%

We got responses from graduates from the class of 1933 all the way up to 2010. Though significant numbers do not start until graduates from perhaps 1947. If we take graduates from 1933-1971, the response rate was 22% and graduates from 1972-2010, the response rate was 18%.

We were not able to send reminders to the Humanities alumni, so if we exclude them from the sample, we are now at a 24.2% response rate. Though by numbers, we got the most responses from H&S alumni (8,336), we got the highest response rate from Earth Sciences and Education alumni (30% returned a survey). 1,134 out of 1,903 Stanford faculty responded (59.6%) and we received 974 responses (53%) from Stanford research staff that were contacted.

A multivariate regression predicting response was performed to further assess response rate characteristics among the alumni sample. The dependent variable is equal to one if the individual responded to the survey and zero otherwise. Due to the large sample size, we see many variables are statistically significant. The first column indicates that women were 5.1% more likely to respond than men overall. Those in more recent graduation years were 0.9% less likely to respond. Graduates of the Education and Medical schools were more likely to respond and those from Law and Engineering were less likely to respond. Finally, we include fixed effects for graduation year, and a full set of interactions between gender and graduation year and school. In this model, we do not detect significant differences for the main effects of gender and school. This indicates that there were specific graduating classes and schools with different response rates by gender. Future work can use these regressions to calculate weights to un-bias the statistics or can eliminate graduation years with response bias. In this paper, we use these response rate differences by gender, school and graduating class to correctly weight the estimates.

Logit regressions on responder status

	Pr(respond)	Pr(respond)	Pr(respond)	Pr(respond)
Gender (female=1)	1.051** (0.018)			1.143 (0.514)
Earth Sciences			1.074 (0.053)	0.535 (0.550)
Education			1.183*** (0.039)	0.662 (0.905)
Engineering			0.883*** (0.020)	0.280 (0.236)
Law			0.741*** (0.027)	0.565 (0.185)
Medicine			1.698*** (0.048)	0.170 (0.162)
Humanities & Sciences			0.508*** (0.011)	
Graduation Year		0.991*** (0.000)		
Gender*Graduation year FE				YES
Gender*school FE				YES
Graduation Year FE				YES
Constant	0.141*** (0.001)	5.69e+06*** (5,022,770)	0.292*** (0.006)	0.273 (0.223)
Observations	133,916	139,004	143,632	70,926

*** p<0.001, ** p<0.01, * p<0.05

This survey was in collaboration with the Stanford School of Engineering, the Graduate School of Business, the School of Humanities and Sciences, the School of Medicine, the Law School, the School of Education, and the School of Earth Sciences.

ESTIMATION METHODS

As in all surveys, a large segment of the alumni population did not respond. Therefore, estimation of the total impact of Stanford alumni entrepreneurs requires extrapolation to account for non-respondents. To give an accurate estimate of the entrepreneurial activity of those who did not respond, a scale factor was used. Since Stanford has data from the 2011 surveys with adjustments from the 2011 Dun & Bradstreet databases, the appropriate scale factor was determined based on the particular statistic or question being answered. Details about how specific scale factors were calculated are found at the end of this section.

The scaling method is based on three assumptions:

- The proportion of entrepreneurs among the respondents is the same as the proportion of entrepreneurs among the non-respondents.
- Respondent entrepreneurs are equally successful as the non-respondent entrepreneurs.
- Entrepreneurs responded with information about all of their founding attempts.

Estimates are likely to be conservative and an undercount of the true economic impact for several reasons.

- The Stanford Innovation Survey went out to 143,482 alumni out of 191,332 total living Stanford degree-holders. The 47,850 individuals either had no contact information on record or were on a “do not contact” list which is typically composed of some of the very most successful and wealthy alumni.
- Only firms founded or co-founded by Stanford alumni are included. Additional data on firms in which Stanford alumni were early employees, investors, board members or advisors are not included.
- Data on many high-profile firms where the founders did not respond or are no longer living are not included.
- Some alumni reported founding a firm but did not provide information about that firm. No adjustments were made for this source of omitted data; it was implicitly assumed these individuals did not actually found firms.
- Some alumni indicated having started more than six firms, however we only aggregated data for up to six firms founded for each entrepreneur.
- Only currently active firms and not failed startups are counted, even if these firms survived a number of years before failing.
- Firms that were partnerships, LLCs, informal ventures or non-profit ventures are included in the dataset, but were not included in these aggregate numbers.
- Finally, the economic impact of Stanford faculty and staff who have licensed inventions to existing companies are not included in the numbers presented here.

Although many different Stanford alumni-founded companies are identified in various discussions throughout this report, only data provided by alumni completing the 2011 survey are included in estimates. As a result, some very significant Stanford alumni firms were NOT included in the database, including Google, Hewlett-Packard, eBay, Cisco, Yahoo!, NVIDIA, Sun, and Intuitive Surgical. These omissions occurred because the Stanford founder or co-founder filled out the survey anonymously, did not respond, or was no longer living. This illustrates the importance of the scale factor employed to produce an accurate estimate to compensate in part for the many firms not included. HP, Cisco and Google have total annual revenues of \$198.8B. So if we were to add them in it would only make it \$2.9 trillion instead of \$2.7 trillion. If we were to add in the top twenty in sales, these total \$255B and so we'd have \$2.96 trillion instead of \$2.7 trillion (a 9.4 percent difference in magnitude). Given the response rate, we should expect (~25 percent) of the top 12 companies are represented in the survey and this is what we found, reassuring us that the sample is representative and the larger companies were not more likely to respond to the survey than less successful firms.

How wrong could these estimates be? Despite reasons that point to a potential underestimation, there are remaining concerns about an overly optimistic estimation. For example, one might disagree with our assumptions and argue that the proportion of entrepreneurs among respondents is higher than that among non-respondents because it is more likely for an entrepreneur to respond to an “innovation survey”. One might also argue that our respondent entrepreneurs are on average more successful than non-respondent entrepreneurs. While it is difficult to precisely determine the non-respondents’ entrepreneurial performance, we provide

several points of reference below by conducting new estimations using significantly more conservative scale factors.

First, to address the potential difference in likelihood to be an entrepreneur, we assume that a non-respondent is 75% as likely to be an entrepreneur as a respondent. This new assumption reduces the scale factors across the board and leads to a tally of 4.2 million jobs created and total annual revenues of \$2.1 trillion. The new figures are about 20% less than our main results -- 5.4 million jobs and \$2.7 trillion in revenues. Second, to address the potential difference in entrepreneurial success between respondents and non-respondents, we further assume that non-respondent entrepreneurs generate 75% as much revenue and employ 75% as many people as respondent entrepreneurs. This brings our results down to 3.4 million jobs created and \$1.7 trillion in revenues, which are about 35% less than the main results.

To paint a more drastic picture, we assume that a non-respondent is only 50% as likely to be an entrepreneur as a respondent. Consequently, we arrive at 3.1 million jobs created and \$1.5 trillion in revenues. If we further assume that non-respondent entrepreneurs are half as successful as respondent entrepreneurs. The numbers drop to 2 million jobs created and \$1 trillion in revenues.

Lastly, we benchmark the economic impact of the Stanford-founded companies against that of new businesses founded in the general economy. We refer to the Kauffman Firm Survey (KFS), which traces the development of more than 4,000 businesses founded in the U.S. in 2004. Specifically, the average revenue of KFS firms in 2008 (5th-year revenue) is \$850,000. To control for the number of years since founding, we look at the firms founded in 2006 within our Stanford dataset, since their reported revenues are most likely those of 2010. We find that the average revenue for the Stanford firms is \$1.8 million. Whereas the Stanford average is higher than the KFS average, it exhibits a significant skew to the right (median = \$500,000), signifying the presence of large outliers pulling the average up. Meanwhile, it is important to point out that the KFS firms reported their revenues in the midst of the very bad financial crisis (their average revenue in 2007 is \$1.15million, 35% higher than 2008), whereas by 2010, the year for which the Stanford companies reported their revenues, economic conditions had improved substantially. Therefore, it might be better to assume a 5th-year revenue of around \$1million for firms founded by the general population.

The difference between the Stanford-founded (mean revenue = \$1.8million) and the KFS firms (mean revenue ~ \$1million) can be attributed to both human capital effect and response bias. While it is difficult to dissect how much each factor weighs in, we can derive an upper bound to response bias: if we could attribute all the difference between Stanford-founded firms and firms founded by the general population to response bias, we would have overestimated Stanford entrepreneurs' economic impact by around 80%.

BENCHMARK COMPARISON OF STANFORD ALUMNI FIRMS TO OTHER UNIVERSITIES

Stanford's Eesley is one of two authors of the MIT alumni survey, and as a benchmark, the results of the Stanford survey can be compared to the MIT survey. A very similar methodology was used (Roberts and Eesley, 2009; 2011; Eesley, 2011). The MIT alumni survey has also been

used in peer-reviewed academic publications (Hsu, Roberts & Eesley, 2007; Roberts and Eesley, 2011).

The total population of MIT alumni is 105,928; 43,668 responded to the first wave of the survey. If you adjust for the differences in alumni population size (Stanford's 142,496 and MIT's 105,928), that is a ratio of 1.345. It would result in an "MIT adjusted for size" jobs estimate of 4.4 million, revenues of \$2.5 trillion, and the number of companies 34,700. These estimates for the Stanford survey were 5.4 million jobs, \$2.7 trillion in revenues and 39,900 currently active firms. Therefore, our estimates appear to be of a reasonable scale relative to prior surveys.

Another benchmark is the 1997 Stanford GSB survey. In 1997 William Barnett and Stanislov Dobrev (2005)¹⁸ surveyed the alumni of the Stanford Graduate School of Business. They received 5,283 completed (or partially completed) surveys for a response rate of 43 percent.¹⁹ The percentage of GSB alumni who reported having been entrepreneurs was 24 percent. Their survey was before the height of the dot.com boom. In our survey we find that 28 percent of the GSB alumni have founded firms – a reasonable increase given the dot.com Internet boom in the late 1990s and falling costs since then of founding an Internet firm.

As expected, these percentages are higher than what might be found in the general population. Jolly et al. (2009) conducted an alumni survey of Iowa State University alumni.²⁰ Using a proportional random sample, surveys were sent to 25,025 alumni, and 5,416 responses were received. They find that 16 percent of the alumni have started businesses, mostly in Iowa.

Another benchmark comes from the economic impact of venture capital funded firms. It is important to keep in mind that the Stanford alumni database contains about ten times as many startups that were never venture capital funded as those that received VC. IHS Global Insight and the National Venture Capital Association in 2010 estimated the total number of jobs created by venture capital-backed companies to be 12 million and the total revenues to be \$3.1 trillion. There have been over 27,000 venture capital-funded firms since 1970. Compared with these numbers and the fact that Silicon Valley represents the largest geographic region for VC investment, our estimates once again appear to be reasonable.

Another test of whether respondent entrepreneurs were more successful on average is to benchmark revenues per employee, a common productivity measure. Stanford alumni firms might be relatively more successful than the representative firm, but the numbers should be in the same broad ballpark. The average revenue per employee in the sample is approximately \$500,000. The average for the NASDAQ 100 is about \$500,000. However, the median revenue per employee in the sample is \$63,000, so the high average is clearly coming from outliers. The

¹⁸ Dobrev, S.D., W.P. Barnett. 2005. Organizational Roles and Transition to Entrepreneurship. *Academy of Management Journal* 48(3), 433-449

¹⁹ Lazear (2004) notes that the response rate may have been even higher if one takes into account that some individuals were very old and others may no longer have been alive to receive the surveys.

²⁰ The Iowa State summary report is available here: http://www.econ.iastate.edu/research/webpapers/paper_13031_09002.pdf

Stanford (and MIT) sample is more highly weighted towards manufacturing, high tech and high-volume software companies than the U.S. average so this is likely to account for a share of the higher average.

A few examples of very successful firms can help gauge whether a very skewed distribution in outcomes might account for the higher average but lower median numbers. In regard to revenues per employee, 33,000 Google employees generated \$37.0 billion in revenues in 2011, or \$1.15 million per employee; 80,000 Koch employees generated \$100 billion, or \$1.25 million per employee. So it's clearly possible for some of the companies to have a high revenue per employee number. A look at industries with over \$1M revenue per employee shows they are primarily in software, Internet, manufacturing industries and finance.

In examining the study results, it is useful to keep in mind three data-related issues: representation, response rates and self-reporting. Survey respondents are representative of the broader Stanford population. Response rates across gender, schools, and graduation years were fairly similar, with older alumni being just slightly more likely to respond compared to recent graduates. The first concern about representativeness is the extent to which inferences made from this dataset apply to entrepreneurship in general. The data for this study come from alumni of a distinguished academic institution, known for its technology-based entrepreneurship and commercialization. These are alumni and therefore the sample is not limited to those currently associated with Stanford or to technology coming from Stanford. They have had diverse experiences before, during and after their time at Stanford. It may not be possible to generalize across the spectrum of entrepreneurial activity. Moreover, comparing national samples of entrepreneurship is not easy; sampling strategies vary depending on the subject matter. It is difficult to compare, for example studies of self-employment (Blau, 1987) and manufacturing (Dunne et al., 1988).

Another issue is possible response bias. Graduates who started a company but were unsuccessful may not have reported these failed firms. As an associated issue, responses from non-U.S. based alumni are likely to be somewhat less representative than their U.S.-based counterparts. Finally, there is the issue of self-reporting. Older respondents, especially those who have started multiple companies, may display a memory bias in which some companies, possibly those that were relatively unsuccessful, are not reported. While these limitations may provide reason for caution on making generalizations from the data, the economic impact reported is large enough that such bias is not significant. Since the dataset is quite large, the sources of bias would have to be highly systematic to have had a large impact.

AN EXPLANATION OF SCALE FACTORS USED

1. We used 84 separate scaling factors because the response rate to the survey can take into account response rates broken out by graduation year, school and gender. This is a major improvement on the earlier methodology used by the MIT alumni survey. For survey items where we have data on all companies created over the life of the entrepreneur, the base scale factor for revenues is approximately 8.425 (i.e., $5.204 * 1.619 = \sim 8.425$). These numbers are approximate since the actual response rate by school, graduate decade and gender is used: these rates vary from 13.7 percent for the School of Humanities and Sciences to 21.1 percent for the Engineering School. Additionally, the calculations used more than three digits after

the decimal. A multiplier of 5.204 was used because, as indicated above, the total population of Stanford alumni is 142,496 and 27,380 alumni responded to the survey.²¹ Examples of other scale factors:

- a. Not all entrepreneurs provided revenue or employee number or a firm name to allow us to match to Dun & Bradstreet. Numbers from the Dun & Bradstreet database were used if a firm name was provided; for those providing no firm name, it was assumed that the companies were no more and no less successful than the other entrepreneurs on average. On average, across the schools 62 percent of the alumni provided revenue and employee data. To adjust for those who responded but did not provide the firm name or revenue, a multiplier of 1.619 was used. Since 8,348 indicated that they had founded a new organization, yet only 7,098 responded with specifics, a factor of 0.992 was used to allow for multiple alumni on the same founding team and avoid duplicate counting. Because 27.9 percent of the reported companies were out of business by 2011, only companies that are still active were counted.
2. For most items (revenues, employees, etc.), respondents provided data on each of the firms founded (up to six firms). For items where data was only provided on one of several companies founded, a multiplier of 2.003 was used, since this is the number of companies on average each entrepreneur has founded (40 percent of Stanford's entrepreneurial alumni are repeat/serial entrepreneurs). For example, of 100 alumni entrepreneurs, on average 200 companies were founded during their careers. Also, the average number of companies for alumni of the same school (Engineering, Education, etc.) was used.
3. As noted above, the scaling factor was also adjusted for items where data are missing. This gives a much more accurate estimate.²²
4. Only incorporated and not yet incorporated firms were considered in the analysis. Dropping the LLCs, informal businesses, non-profits, and partnerships biases the estimates downwards, since many firms start out as LLCs before incorporating. However, the goal was to create conservative estimates that did not include one-person consulting firms and other forms of self-employment, such as medical practices, architecture offices and law offices.
5. All revenue numbers are adjusted for inflation to 2011 dollars. Revenues were for the last year the firm was in operation; for acquired firms it was for the last year before acquisition.

References

"The Making of Silicon Valley: A One Hundred Year Renaissance", Ward Winslow Editor, The Santa Clara Valley Historical Association, 1995

"Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region", Martin Kenney Editor, Stanford University Press, 2000.

²¹ An additional 403 non-alumni faculty and research staff responded to the survey as well.

²² Similar extrapolation methods were used in a recent study of immigrant entrepreneurs' role, using a scale factor to extrapolate from 2,054 responses in their survey database to the estimated economic impact drawn from 28,776 companies, a scale-up factor of ~14.010 (Wadhwa et al., 2007).

"Fred Terman at Stanford", C. Stewart Gillmore , Stanford University Press, 2004.

"The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship", Chong-Moon Lee, William F. Miller, Marguerite Gong Hancock, and Henry S. Rowen Editors, The Stanford University Press, 2000.

Blau, D.M., 1987. A time-series analysis of self-employment in the United States. *The Journal of Political Economy* 95 (3), 445-467.

Chen, Henry, Paul Gompers, Anna Kovner, Josh Lerner. 2010. Buy local? The geography of venture capital. *Journal of Urban Economics*.

Dobrev, S.D., W.P. Barnett. 2005. Organizational Roles and Transition to Entrepreneurship. *Academy of Management Journal* 48(3), 433-449.

Dunne, T., Roberts, M., Samuelson, L., 1988. Patterns of firm entry and exit in U.S. manufacturing industries. *Rand Journal of Economics* 19, 495-515.

Eesley, Charles E. 2011. Alumni Surveys as a Data Collection Methodology. Working paper. Available at: http://www.stanford.edu/~cee/Papers/Eesley_Alumni_surveys.pdf

Hsu, David, Edward Roberts, and Charles Eesley. 2007. Entrepreneurs from Technology-Based Universities: Evidence from MIT, *Research Policy*, 36, 768-788.

Jolly, Robert W., Li Yu, Peter Orazem. 2009. After They Graduate: An Overview of the Iowa State University Alumni Survey. Iowa State University Economics Working Paper Series # 09002.

Hall, Robert E., Susan E. Woodward. 2007. The Incentives to Start New Companies: Evidence from Venture Capital. NBER Working Paper No. 13056.

Lazear, E.P., 2004. Balanced Skills and Entrepreneurship. *American Economic Review* 94 (2), 208-211.

Roberts, E.B.; Eesley, Charles. 2009. Entrepreneurial Impact: The Role of MIT. Kauffman Foundation.

Roberts, Edward and Charles Eesley. 2011. Entrepreneurial Impact: The Role of MIT – An Updated Report. *Foundations and Trends in Entrepreneurship*: Vol. 7: No 1-2, pp 1-149.

Wadhwa, Vivek, AnnaLee Saxenian, Ben Rissing, and Gary Gereffi. America's New Immigrant Entrepreneurs: Part I (January 4, 2007). Duke Science, Technology & Innovation Paper No. 23. Available at SSRN: <http://ssrn.com/abstract=990152>.